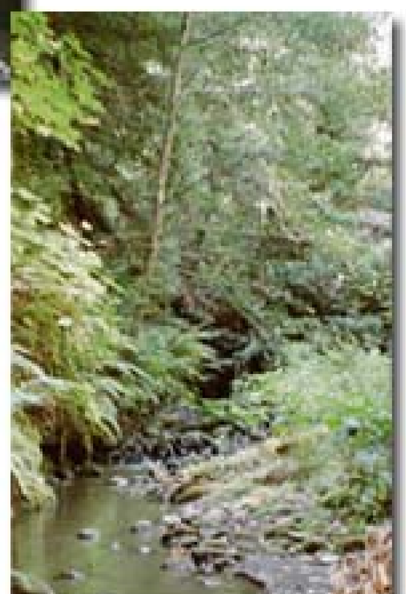

APTOS CREEK FISHERIES HABITAT ASSESSMENT

Technical Memorandum

Prepared for: **Coastal Watershed Council**

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APTOS CREEK WATERSHED ASSESSMENT AND ENHANCEMENT PLAN: SALMONID HABITAT AND LIMITING FACTORS ASSESSMENT

This Technical Memorandum was prepared to document one of several tasks supporting the Coastal Watershed Council in development of the Aptos Creek Watershed Assessment and Enhancement Plan. In conjunction with the results of other tasks, including a hydrologic and water quality assessment, geomorphic and erosion/deposition assessment, and riparian overstory description and mapping, this document provides a basis for developing site-specific habitat protection and restoration projects to benefit native steelhead and coho salmon populations.

1.0 Summary of Existing Information

Aptos Creek has long been recognized as an important steelhead spawning and nursery stream (California Department of Fish and Game (CDFG) stream surveys 1934, 1960, 1965, 1975). A 1960 stream survey estimated abundance of steelhead/rainbow trout at up to 65 per 100 feet and abundance at 40-50 per 100 feet for much of the lower section to the mouth. A 1965 survey estimated that there were 8 miles of nursery area with the average number of rearing steelhead/rainbow trout estimated at 100 per 100 feet of stream except for a half mile section with density of 140 trout per 100 feet of stream.

Aptos Creek is near the southern extent of the known range of coho salmon in North America. Coho salmon have been documented historically as far south as the Pajaro River although there are undocumented reports that they occurred as far south as the Santa Ynez River (Anderson1995). Coho runs disappeared from most streams south of San Francisco Bay during the late 1960's, 1970's, and early 1980's and were last reported from Aptos Creek in 1973. Non-native coho were stocked in Aptos Creek, along with other coastal streams, by the Department of Fish and Game during the 1960's including a large plant in 1963 of 10,000 Alsea stock fish reared at Darrah Springs hatchery in Shasta County (Evans 1963).

Fish sampling and habitat assessments were conducted in both Aptos and Valencia Creeks in 1981 as part of a regional assessment for Santa Cruz County (Harvey & Stanley Associates, Inc. 1982). Compared to other streams surveyed that year, abundance of smolt sized trout was relatively high in Aptos Creek upstream of the second bridge (reach 5 in the present survey) and in Valencia Creek near the Valencia Road crossing (Table 1). Downstream reaches of Aptos Creek had lower densities of smolt sized trout, particularly downstream of Valencia Creek. The study rated the rearing capacity of Aptos Creek as fair to below average at sites downstream of the second bridge and good at the upstream sites. Rearing capacity in Valencia Creek was rated as good at the site downstream from Valencia Road and fair at the site upstream. Primary limiting factors identified in the study included substrate, cover, and spawning in Aptos Creek and pool depth, substrate, and flow in Valencia Creek.

Average pool depths in 1981 ranged from 0.75 to 1.3 feet in Aptos Creek and from 0.45 to 0.6 feet in Valencia Creek. In Aptos Creek bedrock and sand comprised 53% to 90% of the substrate in pools and from 25% to 68% in riffles and runs. In Valencia Creek bedrock and sand made up 70% to 85% of substrate in pools but only 30% to 48 % in riffles and runs. Gravel and cobble substrate in riffles and runs was 30% to 65% in Aptos Creek and 50% to 70% in Valencia Creek. The present study found significantly changed conditions in Valencia Creek with respect to pool depth and substrate conditions. Large amounts of sand substrate were deposited in Valencia Creek during the wet winter of 1982 (J. Smith, San Jose State University, personal communication). Additional sedimentation may have occurred during wet winters in the

Table 1. Rearing Densities of Smolt-sized Steelhead in Santa Cruz Streams

Stream	Average Number of Smolt-
San Vicente	40.9
San Lorenzo River	29.8
Aptos (Nisene Marks, upstream from 2nd Bridge)	24.0
Zayante	22.0
Carmel	21.8
Valencia (downstream of Valencia Road)	17.0
Browns	16.5
Corralitos	16.1
Valencia average	15.0
Baldwin	13.8
Valencia (up flume road 0.75 miles	13.0
Newell	13.0
Shingle Mill Gulch	12.7
Bear	12.0
Fall	12.0
Soquel West Fork	11.3
Aptos (County Park above railroad crossing)	11.0
Boulder	10.5
Mill (San Lorenzo)	10.5
Aptos Average	9.6
Bean	9.5
Majors	9.4
Jamison	8.0
Hester	7.0
Laguna	7.0
Aptos (just above Valencia)	6.0
Aptos (Nisene Marks, upstream from Steel Bridge)	6.0
Bates	6.0
Liddell	6.0
Pescadero	6.0
Ramsey	6.0
Soquel East Fork	6.0
Kings	5.0
Liddell West Fork	5.0
Moore's Gulch	5.0
Gamecock	4.0
Hinkley	3.0
Liddell East Fork	3.0
Lockhart Gulch	3.0
Soquel	3.0
Carbonera	1.7
Aptos (below Valencia)	1.0

Source: Harvey and Stanley Associates (1984)
Notes: Numbers shown in red are within the Aptos/Valencia Creek watershed

mid- to late 1990s. Changes in sediment composition since 1981 may have resulted in changes in trout density. Abundance of rearing trout downstream of Valencia Road was about 70% of that at the best site in Aptos Creek in 1981. This contrasts to the present survey where abundance of rearing trout in that reach of Valencia Creek was only 10%, at best, of that in upper Aptos Creek (based on visual observations).

Aptos and Bridge Creeks also apparently suffered during the winter of 1982. United States Geological Survey (USGS) gage data shows flows reached a peak of 3,980 cubic feet per second (cfs) on January 4, 1982. Stream surveys in Bridge Creek by CDFG in June 1982 concluded that there was virtually no habitat to support an anadromous fishery and that no fish were observed in the creek. It was noted that high water marks on trees indicated a stage increase of 20 feet. High levels of sedimentation were also noted with many landslides and debris jams. Previous surveys in 1960 found that the stream was a good spawning and nursery stream below the natural falls and steelhead/rainbow trout of 2 to 6 inches were seen throughout the lower and mid sections in fair numbers.

A stream survey in the summer of 1982 in Aptos Creek found that there were no spawning areas, most pools were filled in with silt and averaged less than 6 inches in depth, and no fish were seen except an unidentified cyprinid. It is interesting to note that a 1975 survey of Aptos Creek estimated substrate characteristics as 10% fine gravel, 25% coarse gravel, 35% fine rubble, and 25% coarse rubble while the 1982 survey noted 80% sand and silt, 15% boulders and rubble, 4% bedrock, and 1% gravel. A 1985 survey of Aptos Creek indicates that conditions may have improved significantly from 1982. The survey indicated that abundant yearling steelhead were present although few young-of-year were seen. Pools were estimated to be about 50% of the length surveyed with depths up to 5 feet. Substrate was reported as a mosaic of silty sand and rubble upstream of Highway 1. Habitat conditions in Bridge Creek also appear to have improved since 1981 based on abundance of rearing juveniles in the present survey.

CDFG conducted qualitative sampling in Aptos Creek in 1996 and found densities of 1+ and older trout between 1.8 and 25.8 per 100 feet in pool type habitat. This is roughly comparable to the results for 1981. Both the 1981 and 1996 estimates appear to be well below estimates from the 1960's, however the earlier estimates are not well documented.

A stream inventory was conducted by CDFG in Aptos Creek watershed during 1997. Significant findings included:

- Limited water temperature sampling indicated temperature conditions near the upper optimal limit for juvenile salmonids in Valencia, Aptos, and Bridge Creeks.
- Numerous rock dams were constructed within the creek, preventing upstream movement of juvenile fish in Aptos Creek.
- Trash was being dumped and accumulating in the lower part of Aptos Creek.
- Several trees had been cut up and left in Aptos Creek below The Forest of Nisene Marks State Park.
- Most of the existing cover in Valencia Creek was provided by small woody debris and the habitat could benefit from more large woody debris.
- Most existing cover in Trout Creek is from boulders, woody cover in pools, and flatwater should be increased.
- A need to inventory, map, and treat sediment sources was identified in Valencia, Trout, and Aptos Creeks.

2.0 Habitat Requirements for Steelhead and Coho Salmon in Aptos Creek Watershed

Steelhead/rainbow trout and coho salmon habitat requirements are associated with distinct life history stages including migration from the ocean to inland reproductive and rearing habitats, spawning and egg incubation, rearing, and seaward migration of smolts and spawned adults. Steelhead/rainbow trout have a highly flexible life history and may follow a variety of life-history patterns including residents (non-migratory) at one extreme and individuals that migrate to the open ocean (anadromous) at another extreme. Intermediate life-history patterns include fish that migrate within the stream (potamodromous), fish that migrate only as far as estuarine habitat, and fish that migrate to near-shore ocean areas. These life-history patterns do not appear to be genetically distinct, and have been observed interbreeding (Shapovalov and Taft 1954). Habitat requirements and life-history timing for steelhead can vary widely over the steelhead's natural range (Barnhart 1986; Pearcy 1992; Busby *et al.* 1996).

Coho salmon have a more rigid life history with less variable life history patterns and timing. All coho salmon in California Coastal streams migrate to the ocean to mature and all adult coho die after spawning. Essentially all California wild female coho salmon spawn at 3 years of age. This results in three distinct brood year lineages in each stream. Extreme events in any given year (floods, droughts, toxic spills, etc.) that dramatically reduce or eliminate a single year class will result in the loss or reduction of the entire lineage and will be expressed as a low or missing run every third year (Anderson 1995). Under natural conditions, depression of any lineage will continue until it is rebuilt by straying or exceptionally good reproduction from a small residual spawning population.

The following paragraphs describe general life history traits and habitat relationships for steelhead and coho salmon. Some of the best information on steelhead and coho life histories comes from a multi-year study in Waddell Creek in the Santa Cruz mountains (Shapovalov and Taft 1954) and that study provides a basis for much of the following discussion.

2.1 In-migration of Adults

Steelhead and coho along the Central California coast enter freshwater to spawn when winter rains have been sufficient to raise streamflows and breach the sandbars that form at the mouths of many streams during the summer. Increased streamflow during runoff events also appears to provide cues that stimulate migration and allows better conditions for fish to pass obstructions and shallow areas on their way upstream. The season for upstream migration of steelhead adults lasts from late October through the end of May but typically the bulk of migration (over 95% in Waddell Creek) occurs between mid-December and mid-April. Coho salmon have a more abbreviated spawning season that occurs earlier in the winter. In California, coho spawning migrations occur between late October and early March with more southern populations typically spawning slightly later. Between 1933 and 1942, the coho migration in Waddell Creek occurred between early December and early March with 90% of the run completed by early February (Shapovalov and Taft 1954). This relatively early spawning period for coho salmon increases the probability that their embryos will be exposed to severe conditions during high flow episodes and has resulted in very weak year classes in some of the remaining runs south of San Francisco Bay (Anderson 1995).

Steelhead have strong swimming and leaping abilities that allow them to ascend streams into small tributary and headwater reaches. Steelhead can swim at rates of up to 4.5 feet per second (fps) for extended periods of time and can achieve burst speeds of 14 to 26 fps during passage through difficult areas (Bell 1986). Leaping ability is dependent on the size and condition of fish and hydraulic conditions at the jump. Given satisfactory conditions, a conservative estimate of steelhead leaping ability is a height of 6 to 9 feet (Bjornn and Reiser 1991), though other estimates range from 11 feet (Bell 1986) to as high as 15 feet (McEwan 1999). Coho have slightly lower swimming and leaping ability than steelhead, with cruising speeds up to 3.5 fps and burst speed of 10-21 fps (Bell 1986). Maximum jumping height for coho is reported by Bell (1986) at just over 7 feet. These differences in swimming ability may limit coho to relatively lower gradient reaches of coastal streams. In Waddell Creek, Shapovalov and Taft (1954) found that coho consistently spawned lower in the creek. Coho are known to spawn in very small tributary streams though fry often move out of these smaller tributaries after hatching.

2.2 Spawning and Egg Incubation

Shapovalov and Taft (1954) found no differences in characteristics of spawning sites chosen by steelhead and coho in Waddell Creek. Both species select spawning sites with gravel substrate and with sufficient flow velocity to maintain circulation through the gravel and provide a clean, well-oxygenated environment for incubating eggs. Preferred flow velocity is in the range of 1-3 feet per second for steelhead (Raleigh 1984) and 0.7-2.3 feet per second for coho (McMahon 1983). Preferred gravel substrate is in the range of 0.25 to 4 inches in diameter for steelhead and 0.5 to 4 inches for coho (Bjornn and Reiser 1991). Non-anadromous rainbow trout prefer spawning gravel in the range of 0.25 to 2.5 inches in diameter.

Typically, sites with preferred features for spawning occur most frequently in the pool tail/riffle head areas where flow accelerates out of the pool into the higher gradient section below. In such an area, the female will create a pit, or redd, by undulating her tail and body against the substrate. This process also disturbs fine sediment in the substrate and lifts it into the current to be carried downstream, cleaning the nest area. Incubation and emergence success are influenced by accumulation of fine sediments (generally less than 3.3 mm) in the substrate. Embryo survival for steelhead decreases when the percentage of substrate particles less than 6.4mm reaches 25-30% and is extremely low when fines are 60% or more. Emergence of steelhead and coho fry is generally high when fine sediments are less than 5% of substrate volume but drops sharply with fine sediment volume of 15% or more.

Coho fecundity ranges from about 1,600 eggs for a 22-inch female to over 4,000 for a 30-inch fish. Steelhead have significantly higher fecundity with a 22-inch female producing around 4,800 eggs and a 30-inch fish producing an average of 9,000-10,000 eggs (Shapovalov and Taft 1954). Even a 12-inch non-anadromous rainbow trout may produce 1,000 eggs or more. Survival of fertilized eggs through hatching and emergence from the gravel are most often limited by severe changes in flow that can dislodge eggs from the substrate, result in sedimentation, or de-water incubation sites. Since the majority of coho usually complete spawning by January or early February their eggs are more susceptible to damage from winter storms than steelhead, many of which may spawn as late as March or April. In addition, where the two species occur together, the earlier coho redds may be disrupted by later spawning steelhead.

Steelhead eggs range from 3 to 6 mm in diameter and are mostly spherical. At hatching steelhead larvae (alevins) are approximately 14 to 15.5 mm total length (TL) (Wang 1986; Emmett et al 1991). At completion of yolk sac absorption (~emergence) steelhead larvae are approximately 22-25mm TL. Coho salmon eggs are reported to be from 6.6 mm to almost 8 mm in diameter in the U.S. (they are smaller in Canada). The coho alevins are somewhat larger than steelhead, ranging from 17 to 19 mm at hatching and 27 to 30 mm at emergence (Emmett et al. 1991).

2.3 Rearing

After emergence from the gravel, fry inhabit low velocity areas along the stream margins. As they feed and grow they gradually move to deeper and faster water. In Central California streams coho typically rear for one year in freshwater and steelhead typically rear one or two years. Steelhead juveniles of 4-6 inches (generally in their second year of life) may be commonly found in riffle habitat, particularly in warmer streams. Parr larger than 6 inches are more often found in deeper waters where low velocity areas are in close proximity to higher velocity areas and cover is provided by boulders, undercut banks, logs, or other objects. Heads of pools generally provide classic conditions for older trout. Trout and juvenile coho can inhabit quite small streams, particularly in coastal streams. Often habitat may be far more limiting for older juveniles than habitat for younger fish. The critical period is during base flow conditions that generally occur between May and October in Central California. Streamflow can drop to very low levels with loss of depth and velocity in riffle and run habitats, or in the extreme, only isolated pools with intervening dry sections of stream. Any diversion or other depletion of streamflow during this critical period can be potentially damaging to rearing juvenile steelhead.

Although standard definitions of good trout rearing habitat often include conditions such as baseflows of at least 25% to 50% of the average annual daily flow, 1:1 riffle-to-pool ratios, and depths of a foot or more, these conditions may not always be achieved in Central California streams that still support relatively good steelhead/rainbow trout populations. Steelhead/rainbow trout populations in Central California can occur in streams with relatively low baseflow and in streams varying widely in terms of standard evaluation parameters such as pool:riffle ratio and mean depth. Often, local populations thrive under conditions that may depart widely from species norms (Behnke 1992). Steelhead juveniles respond to stream conditions that limit habitat for older trout by leaving the small streams to complete the maturation process in the more accommodating ocean environment.

Coho parr are most abundant in large, deep pools (greater than 1 foot) with abundant cover in the form of logs, roots, woody debris, undercut banks, and overhanging vegetation (McMahon 1983). Some studies have shown positive correlations between coho standing crop and pool volume (McMahon 1983). Food and cover are key factors for rearing steelhead and coho (Mason and Chapman 1965; Shapovalov and Taft 1954). Food availability, in terms of production of aquatic and terrestrial insects, is influenced by substrate composition, extent of riffles, and riparian vegetation. The highest production of aquatic invertebrates is in gravel and cobble substrate with low amounts of fine sediments, often occurring in riffle type habitats. Production of coho has been shown to be higher in pools with larger riffles upstream (Pearson *et al.* 1970). Coho production decreases with high levels of fine sediments and high embeddedness of cobble substrate (Crouse *et al.* 1981). Bjornn *et al.* (1977) found that the density of rearing steelhead and chinook salmon in artificial channels was reduced in nearly direct proportion to increased cobble embeddedness. Response to increased embeddedness was even greater during the winter. During the high flows, reduced food abundance, and lower temperatures occurring in winter, both coho and steelhead may move into the substrate or other cover. Backwater habitat, small tributaries, or other low velocity areas may also be important winter habitat.

Temperature is an important factor for steelhead/rainbow trout and coho, particularly during the over-summer rearing period. In many Central California streams growth slows or ceases in conjunction with warm, low flow conditions in late summer. The influence of water temperature on steelhead and other salmonids has been well studied and the influence on individual trout populations is complicated by a number of factors such as local adaptations, behavioral responses, other habitat conditions, daily and annual thermal cycles, and food availability. The most definitive temperature tolerance studies have been conducted in laboratory settings where experimental conditions have been highly controlled and fish were exposed to constant temperatures (Brett 1952; Brett *et al.* 1982). Upper lethal temperature for Pacific salmonids is in the range of 75°F to 77°F (24ºC-25ºC) for continuous long-term exposure. Upper incipient lethal temperature ranges from 23ºC to 26ºC for coho fry and is 24ºC to 25ºC for rainbow trout.

Elevated temperature below the lethal threshold can have indirect influence on survival due to depression of growth rate, increased susceptibility to disease, and lowered ability to evade predators. The swimming ability of coho is reduced at temperatures exceeding 20ºC or below 9ºC. Growth of coho is high at 9ºC -13ºC but decreases at 18ºC and ceases at 20.3ºC (McMahon 1983). Preferred temperatures for steelhead parr range from 12ºC to 18ºC, although optimum growth rates may occur at slightly higher temperatures if food is abundant. Temperature also influences the smoltification process. In some studies, steelhead have exhibited decreased migratory behavior and decreased seawater survival at temperature in excess of 55°F (13ºC) (Zaugg and Wagner 1973; Adams *et al.* 1975).

In most streams water temperature varies over the course of a day and from day to day, generally tracking changes in air temperature. Although the peak temperature on a given day may exceed the lethal level, steelhead/rainbow trout can survive short periods at temperatures above the lethal threshold. In Brett's study, juvenile chinook salmon experienced no mortality at temperatures up to 75°F (24ºC) for 7 days. At 79°F (26ºC) half the juvenile salmon survived a 5-hour exposure period and at 81°F (27ºC) half survived a 1.5-hour exposure. The temperature that the fish are acclimated to is also an important variable. Juvenile salmon acclimated to 75°F (24ºC) experienced 50% mortality after 8.5 days at 77°F (25ºC) while those acclimated to 59°F (15ºC) experienced 50% mortality after only 42 hours of exposure at 77°F (25ºC) (Brett 1952). Some trout populations are able to thrive under temperature conditions unsuitable for other populations. Behnke (1992) has found native redband trout in intermittent desert streams thriving in water of 83°F (28ºC) and actively feeding at that temperature. These populations have apparently become adapted to conditions in the region.

Smith (1999) describes two different habitat types used by Central Coast steelhead and resident trout. The primary habitat consists of shaded pools of small, cool, low-flow upstream reaches typical of the original steelhead habitat in the region. In addition, they can use warmwater habitats below some dams or pipeline outfalls, where summer releases provide high summer flows and fast-water feeding habitat. Trout metabolic rate and thus food demand increases with temperature. Trout rely heavily on insect drift for food and drift increases with flow velocity. Under conditions of low flow and high temperatures trout have increasing difficulty obtaining sufficient food to meet metabolic costs. Smith and Li (1983) found that in Uvas Creek (Santa Clara County), a relatively warm stream with summer maximum water temperature of 23ºC to 25°C, steelhead/rainbow trout move into higher velocity microhabitats in riffles and runs where sufficient food can be obtained. These habitats are created by summer releases from an upstream reservoir. Under augmented flow conditions trout can occupy warmer habitats than may otherwise be possible.

2.4 Smolt Out-Migration

Behavior of steelhead/rainbow trout in Waddell Creek is probably typical for most Central California populations. Trout of various ages migrated out of Waddell Creek in all months of the year but the majority migrated in April, May and June. Downstream migration of young-of-year fish (less than a year old) extended from late-April through the following spring; however this movement may have been just dispersal to downstream rearing areas and not a true seaward migration. Downstream migration of 1-year old steelhead was from April through late June and 2-year old fish from March through late May. Coho in Waddell Creek migrated almost exclusively as one-year old fish and 96% of all migration occurred between April 1 and June 15.

In addition to temperature and flow conditions, smolts are subject to predation, primarily by birds including cormorants, mergansers, and herons. Although predation by fish can be high in certain situations, large predatory fish are not present in most smaller coastal streams. Predation by birds can increase under conditions where smolts have to traverse shallow sections of streams without cover. With clear water, birds can be particularly effective predators. Conditions favoring predation by birds occur in channel reaches modified for flood control where the channel is maintained in a wide, shallow configuration and is largely devoid of in-stream large woody debris and riparian vegetation.

2.5 Out-Migration of Adults

All coho die following spawning. Steelhead that survive spawning return downstream to re-enter the ocean. As many as 20% of adult spawners may be repeat spawners and some fish may return to spawn up to 3 or 4 times (Shapovalov and Taft 1954). In some streams fish return downstream immediately after spawning while in others they may remain for a period up to several months. After spawning, these fish do not typically resume feeding while in freshwater. In Waddell Creek the bulk of adults returned downstream from April through June. Fish that remain in the stream for any period of time generally reside in deeper pools. Adequate cover and cool temperature are critical habitat variables for adults that hold over for the entire summer.

3.0 Salmonid Habitat Assessment

3.1 Habitat Assessment Methods

Stream habitat was assessed between late August and early October, 2001 using the California Salmonid Stream Habitat assessment methodology. Surveys were completed in 8.5 miles of Aptos Creek from the mouth upstream to a point southeast of Whites Lagoon. Bridge Creek was surveyed from the Aptos Creek confluence upstream for 1.2 miles. A total distance of 5.2 miles in Valencia Creek was surveyed from the Aptos Creek confluence to approximately 1.7 miles upstream of Valencia Road. Trout Creek Gulch was surveyed from the Valencia Creek confluence to the road crossing 1.3 miles upstream. A short section of Mangels Gulch was surveyed but was mostly dry.

Prior to initiating field surveys, the watershed was segmented into discrete reaches based on gradient, tributary inflow, stream channel type, natural barriers, and other available channel morphology data. Reach designations were confirmed or adjusted during the field surveys based on actual channel conditions.

Stream habitat types were inventoried in accordance with the California Salmonid Stream Habitat Restoration Manual (Flosi *et al.* 1998) with the following modifications:

- Habitat typing was conducted at a Level IV classification using a ten percent sampling protocol (Flosi *et al.* 1998).
- In each sample reach all habitat units were identified by type and length measured. First encounters for each habitat type, and a randomly selected 10% sample was characterized in full detail.
- Maximum depth, pool tail crest depth and pool tail embeddedness were recorded for every pool encountered.
- Canopy density was recorded for every third habitat unit.

- Bank composition and vegetation components were not included since detailed information on these features was collected in the geomorphic and erosion/deposition assessment (Task 2) and riparian and overstory description and mapping task (Task 4).

Habitat assessment data were evaluated by summarizing habitat type frequency of occurrence and parameter values within discrete, homogenous stream reaches. Tabular and graphical summaries were developed to aid in limiting factor analysis.

Potential barriers to migration were identified, located by GPS when possible, photo documented and described with reference to species specific criteria in the scientific literature for passage at both natural and constructed obstacles (Bjornn and Reiser 1991; NMFS 2000; WDFW 1999).

As an additional layer of information and to aid in interpreting the habitat assessment data, visual observations of fish were also recorded during the habitat assessment. Counts by size class and species were recorded on a fish observation datasheet for each habitat unit where fish were observed.

In conjunction with the habitat assessment, large woody debris occurring within the channel was tabulated by size using the protocol outlined in the CDFG Salmonid Stream Habitat Restoration Manual (Flosi *et. al.* 1998). Information describing the impact that large woody debris (LWD) has on channel structure, pool formation and habitat complexity within each reach was also collected.

3.2 Habitat Assessment Results

Six reaches of Aptos Creek and one reach of Bridge Creek were surveyed (Figure 1). The lowest reach of Aptos Creek consisted of the lagoon and a low gradient reach between the lagoon and the confluence with Valencia Creek. The second Aptos reach extended upstream from Valencia Creek for about 1.4 miles and was characterized by relatively low gradient and low confinement. The third Aptos reach (about 1.6 miles) was also relatively low gradient but was more confined, often running between steep bedrock walls, and extended to just upstream of the steel bridge. The fourth Aptos reach was low gradient but less confined than the downstream reach and extended almost 2 miles to near the historic location of the old sawmill. The fifth Aptos reach included the Bridge Creek confluence and extended upstream to a point where the gradient increased and extensive log jams began, near the Loma Prieta epicenter. The sixth Aptos reach extended upstream for about 1.5 miles and was characterized by relatively steep gradient, numerous landslides, and frequent log debris jams. The lower 1.2 miles of Bridge Creek had characteristics similar to the sixth reach of Aptos Creek. Much of Bridge Creek and Aptos reach 6 may be inaccessible to anadromous fish at most times.

Valencia Creek was segmented into three reaches, a higher gradient reach where the stream trends in a more north-south orientation upstream of Valencia Road, and two lower reaches separated at the point where drainage from a large basin to the southeast enters the Creek (Figure 1). Trout Creek was surveyed from Valencia Creek upstream to for approximately 1.3 miles to the vicinity of the Trout Creek Gulch road crossing. Most of Mangels Gulch was dry at the time of the survey. A 13-foot cascade with associated debris jam located approximately 680 feet upstream from the Aptos Creek confluence is a migration barrier. The substrate downstream of the barrier is dominated by sand and the channel bed is uniform (without pool development). Based on these conditions, Mangels Gulch is not expected to support steelhead or coho.

The results of habitat surveys and fish observations were evaluated to identify key factors that potentially limit fish populations in the watershed (Section 4). Several key habitat features were

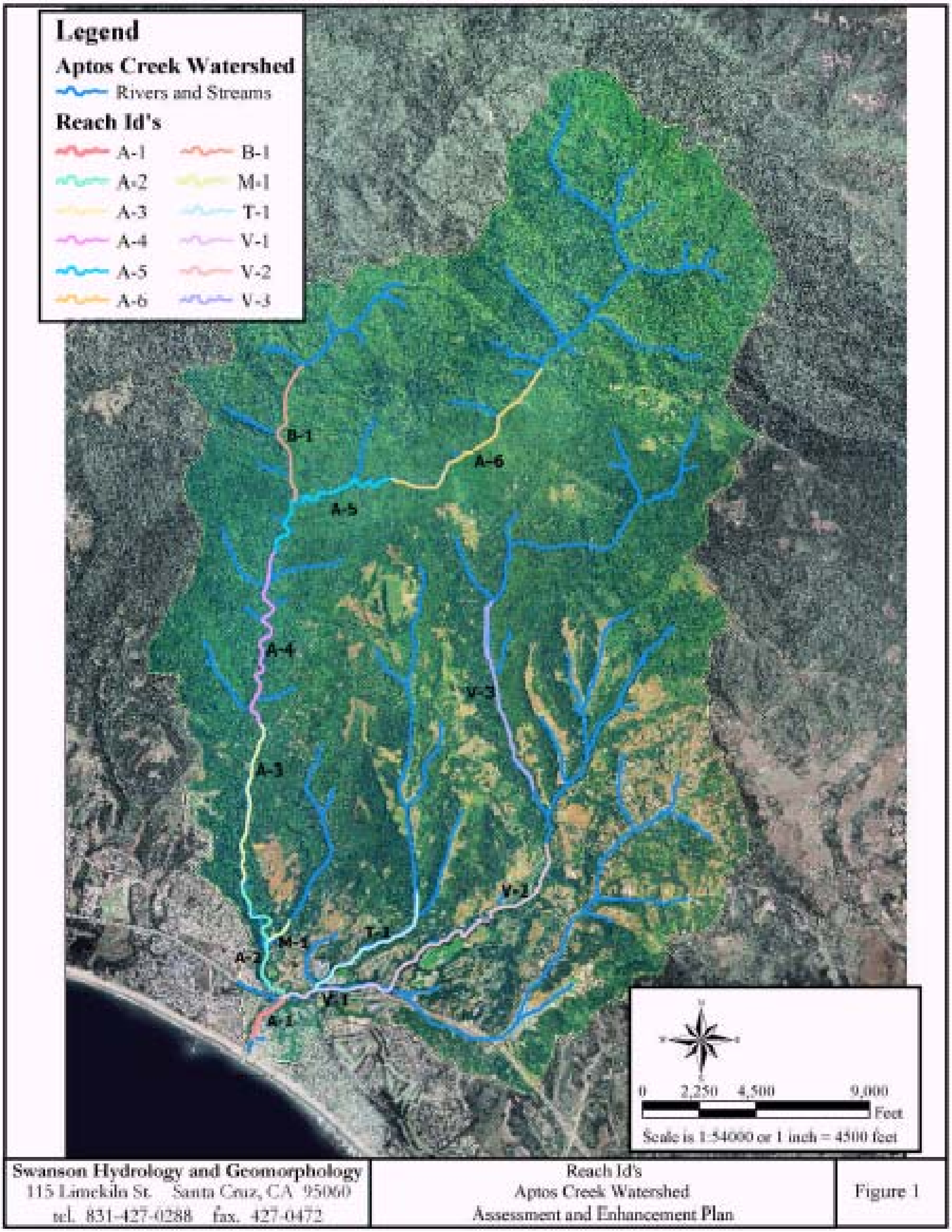


Figure 1. Survey Location Map – Aptos Creek Watershed

considered in determining potentially limiting factors and potential for improvement including habitat type and stream dimensions, shelter characteristics, substrate conditions, bank and canopy conditions, stream temperature, and barriers to fish movement. The discussion of results that follows is organized around these key features.

3.2.1 Habitat Type and Stream Dimensions

The habitat inventory assesses the amount and quality of different habitat types within each reach. Habitat dimensions (depth, area) and type (pool, riffle, flatwater) influence the ability of a stream to support trout and salmon populations. Riffle habitats are important for production of aquatic insects and other organisms used as food sources. Riffles can also provide good habitat for younger age classes of salmonids and can be good foraging areas if they are sufficiently deep. Flatwater runs and glides can also be used for foraging and can support greater numbers of rearing juveniles depending on depth and cover characteristics. Flatwater habitats also tend to have areas where velocity and substrate characteristics are suitable for spawning. Pool habitat is important because pools provide habitat during the summer low flow period and during periodic droughts. Deeper pools with good cover characteristics provide very important habitat for adult resident trout, coho parr, and second year steelhead parr. Although these fish may inhabit pools with mean depths in the range of 0.5 to 1.5 feet in small streams, they generally occur at greater densities in streams with more pools in the 1.5 to 2.5 foot mean depth range or deeper. Excessive fine sediments in a stream may result in loss of pool depth and cover components.

Habitat conditions varied considerably between sub-watershed areas and between reaches within sub-watersheds (Figure 2). Most of Valencia Creek and Trout Creek consisted of narrow, shallow channels with predominantly sand substrate and no pools. Valencia Creek had lower flow and a narrower wetted channel (mean width) than Aptos and Bridge Creeks (Table 2). Depth was less for all habitat types in Valencia and Trout Creeks than in Aptos and Bridge Creeks, even in the smaller, upper reaches of Aptos Creek (Table 3).

As would be expected, estimated discharge and average wetted width in Aptos Creek decreased higher in the watershed as did the amount of pool habitat (% by length) and pool depth (Table 2). Aptos reach 1 was atypical in that approximately half its length included the lagoon. The other half was highly influenced by Valencia Creek and consisted primarily of wide shallow glide type habitat dominated by sand substrate. Habitat conditions improved upstream of Valencia Creek with lower amounts of sand substrate and better habitat development. Pools were most extensive in reach 3 of Aptos Creek where they were typically long and deep with steep bedrock sides (Figure 3). The pools were generally sufficiently deep to support older age classes of resident trout and juvenile steelhead and coho. The great majority of pool habitat (75% to 85% by length) in reaches 2, 3, and 4 of Aptos Creek had mean depths over 1 foot and maximum depths of at least 2 feet (Figures 4 and 5). A significant number of pools in these reaches had maximum depths of 3 feet or more (29% of pools in reach 2, 44% in reach 3, and 40% in reach 4). In the upper two reaches of Aptos Creek and in Bridge Creek, pools were less extensive and more shallow (Tables 2 and 3). Pools in Aptos reach 6 and Bridge Creek were only 18% and 9% of the habitat by length and the majority had mean depth of less than 1 foot and maximum depth of 2 feet or less. This type of habitat would presumably support fewer fish past their first year than the lower reaches. Only three pools were identified in Valencia Creek, all in the uppermost reach (reach 3). A single pool was found in the 7,018 feet of Trout Creek that were surveyed. It was a small deep backwater pool formed by scour around the butt of a redwood log.

Scour against bedrock was the primary pool formation factor in Aptos Creek (Table 4). Wood, in the form of logs or roots was a relatively important pool formation factor in reaches 2 and 3 (41% and 30% of pools, respectively) but was relatively unimportant in the upper reaches, particularly reach 5. Since bedrock pools were longer on average than wood-formed pools, they made up

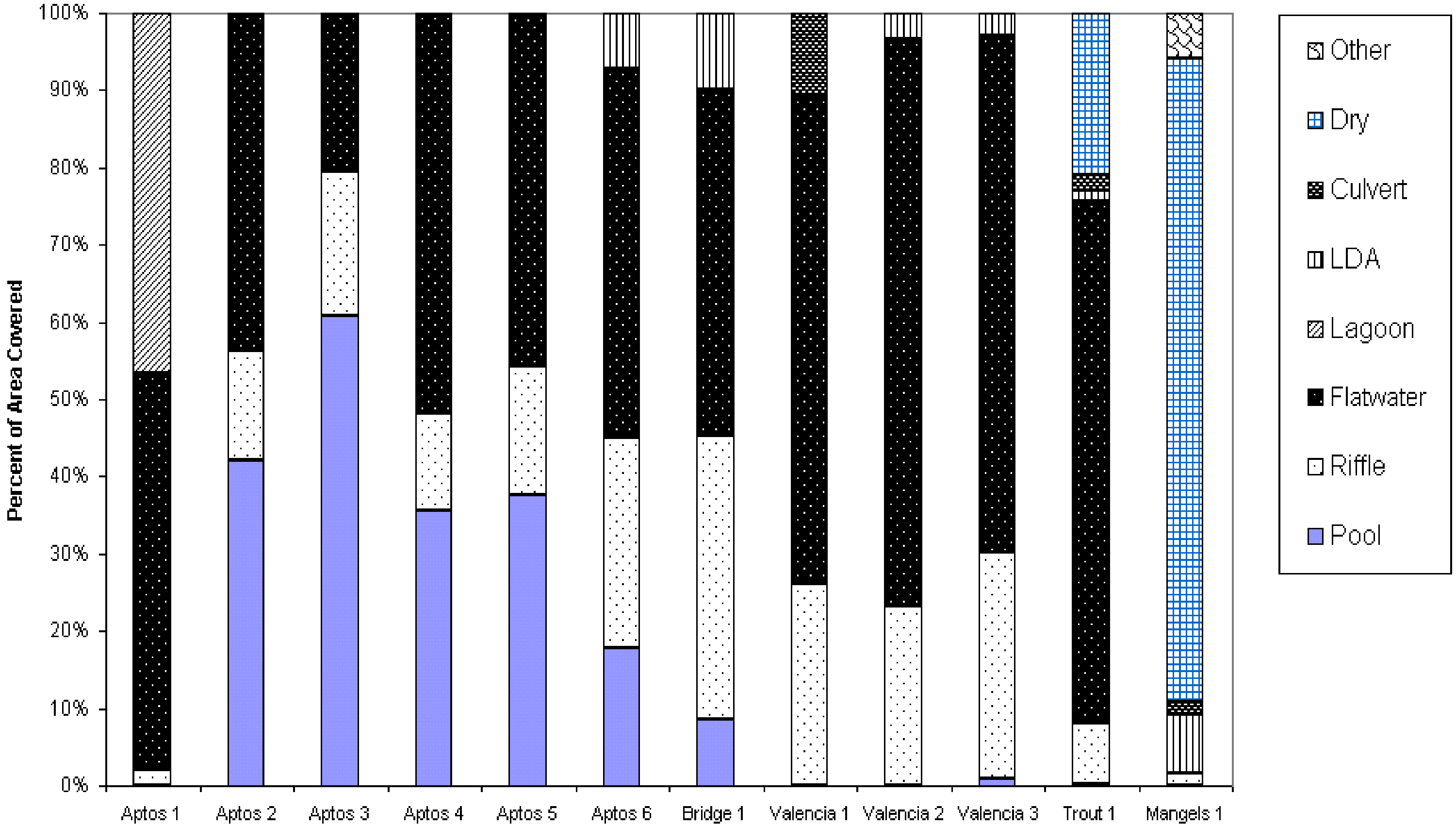


Figure 2. Habitat Type Composition

Table 2. Aptos Creek Watershed Pool Characteristics

	reek						Bridge Creek	Valencia Creek			Trout Creek
		A-2	A-3		A-5			V-1	V-2		
Reach Length (ft)	1,649	7,134	8,340	10,366	9,251	7,952	6,461	5,599	12,581	9,232	7,018
Estimated Flow (cfs)	n.m.	2.5	n.m.	2.5	1.3	1.0	1.0	0.5	0.5	0.5	0.1
Mean Width (ft)	28.8	12.6	14.7	12.8	10.5	8.3	7.8	6.8	6.3	6.9	3.6
Average Pool spacing (ft)	n.a.	183	203	247	189	209	294	n.a.	n.a.	3,077	7,018
Mean Length of Pools (ft)	n.a.	77	124	88	71	37	25	n.a.	n.a.	25	10
Number of Pools	0	39	41	42	49	38	22	0	0	3	1
% pools by length	0%	42%	61%	36%	38%	18%	9%	0%	0%	1%	0
% pools with mean depth >=1.5 ft	*	26%	29%	29%	2%	8%	0%	*	*	0%	+
% pools with mean depth >= 2 ft	*	5%	2%	10%	0%	3%	0%	*	*	0%	+
% pools with maximum depth >= 3ft	*	29%	44%	40%	14%	11%	0%	*	*	0%	+

Notes: ft: feet
cfs: cubic feet per second
n.m.: not measured
n.a.: not applicable, habitat type did not occur in stream reach
*no pools present
+only single pool identified in Trout Creek

Table 3. Depth Characteristics by Habitat Type and Reach

	Aptos Creek						Bridge Creek	Valencia Creek			Trout Creek	Mangels Creek
	A-1	A-2	A-3	A-4	A-5	A-6	B-1	V-1	V-2	V-3	T-1	M-1
	Average of Mean Depth											
Flatwater	0.25	0.55	0.58	0.60	0.43	0.46	0.36	0.15	0.24	0.23	0.06	n.a.
Pool	n.a.	1.34	1.28	1.37	0.99	1.02	0.81	n.a.	n.a.	0.60	1.30*	n.a.
Riffle	0.30	0.35	0.30	0.28	0.33	0.25	0.20	0.15	0.25	0.26	0.06	n.a.
	Average of Maximum Depth											
Flatwater	1.10	1.11	1.05	1.05	0.86	1.26	0.93	0.30	0.70	0.53	0.26	n.a.
Pool	n.a.	2.92	3.04	2.81	2.27	2.13	1.80	n.a.	n.a.	1.30	2.30*	n.a.
Riffle	0.60	0.55	0.64	0.68	0.85	1.05	1.75	0.33	0.68	0.50	0.20	n.a.

Notes: * single pool measured in Trout Creek
n.a. habitat type did not occur in stream reach

Figure 3. Typical bedrock pool in Aptos Creek, reach 3

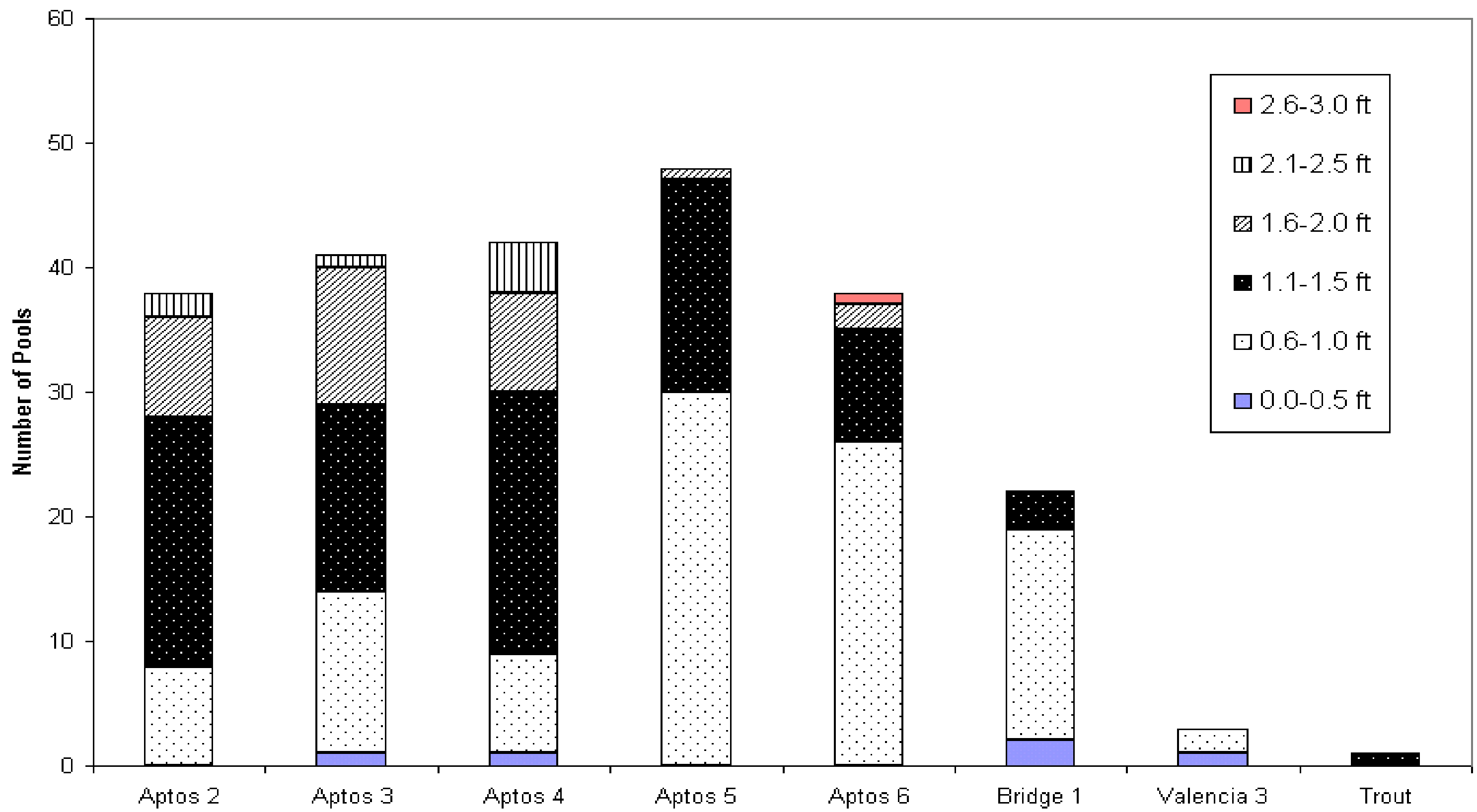


Figure 4. Pool Mean Depth by Reach

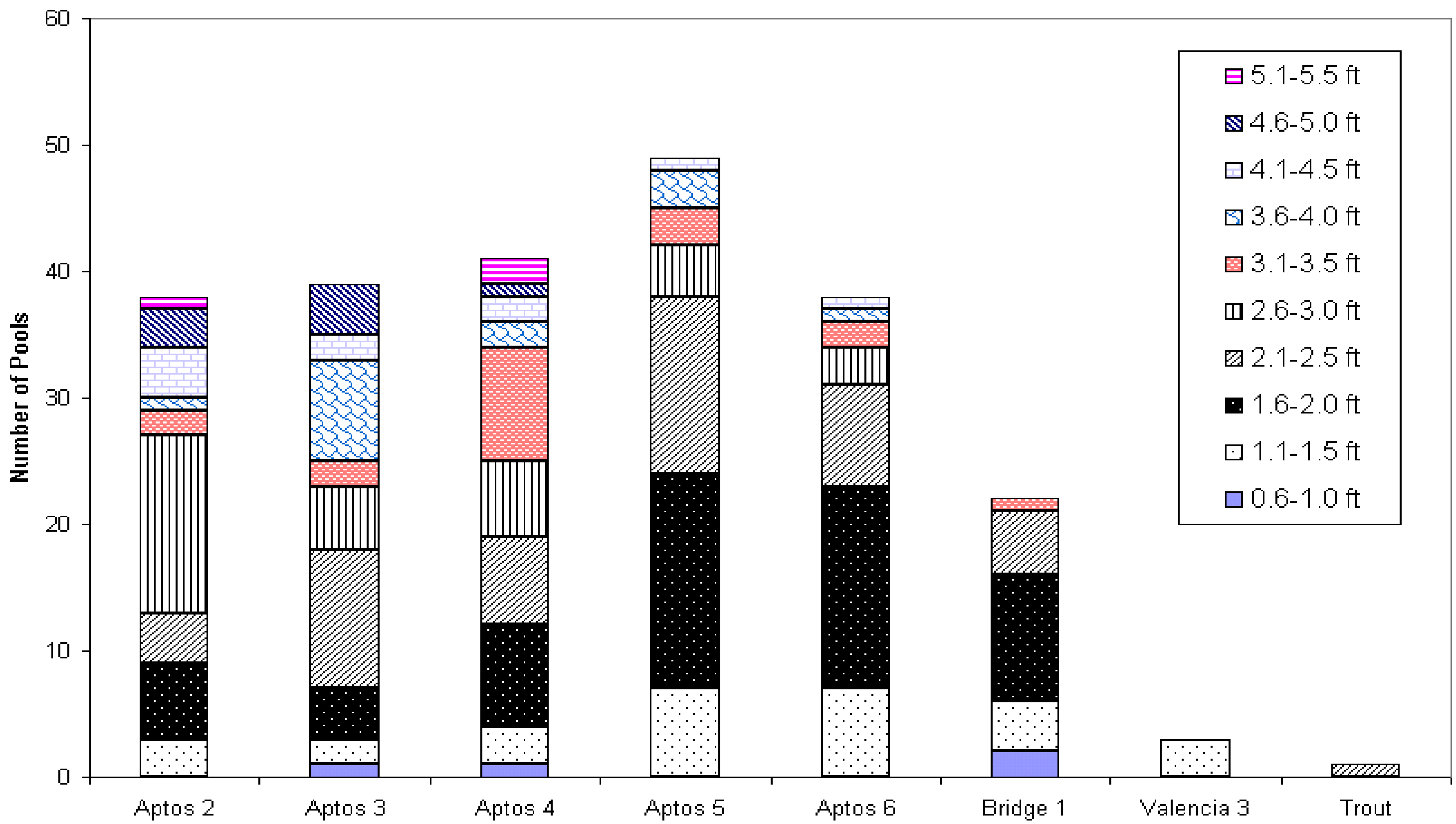


Figure 5. Pool Maximum Depth by Reach

Table 4. Pool Primary Formation Factors by Reach

Habitat Unit Type	Number of Pools					
	Aptos Creek A-2	Aptos Creek A-3	Aptos Creek A-4	Aptos Creek A-5	Aptos Creek A-6	Bridge Creek B-1
Backwater Pool-Log Formed		1				
Dammed Pool		2				
Lateral Scour Bedrock Formed	14	23	30	27	15	7
Lateral Scour Boulder Formed				4	6	2
Lateral Scour Log-enhanced	6	6	4	8	5	4
Lateral Scour Pool	1		1			
Lateral Scour Root-wad enhanced	8	5	2	1	3	
Mid-Channel Pool	5	2	2	6	3	1
Plunge Pool					5	7
Secondary Channel Pool				1		
Step Pool		1			1	1
Grand Total	34	40	39	47	38	22
% pools formed by woody debris	41%	30%	15%	19%	21%	18%
mean length woody debris pools (feet)	72	63	76	48	49	
mean length bedrock pools (feet)	89	160	97	88	35	
woody debris pools, % by length	34%	18%	12%	11%	27%	23%
bedrock pools, % by length	41%	73%	79%	69%	38%	38%

a much greater proportion of the stream length than wood formed pools (Table 4). The contribution of wood-formed pools to habitat should not be discounted. However, since much of the useful habitat in a pool is at the head of the pool , much of the longer bedrock pools may not be used for rearing. In other words, a relatively short wood formed pool may have nearly as much useable habitat as a long bedrock pool. It is surprising that even in reach 6, where a substantial amount of large woody debris was available, it was less important than other factors in pool formation. This is primarily because the available wood was suspended above the channel or was concentrated in debris jams.

Flatwater habitat was relatively extensive in all reaches of Aptos Creek (Table 5). Riffle habitat was relatively scarce in the lower five reaches of Aptos Creek. Flatwater habitat dominated both Valencia and Trout Creeks with lesser amounts of riffle habitat. Flatwater in Valencia and Trout Creeks was shallower and more dominated by sand than in Aptos Creek.

3.2.2 Shelter Characteristics

There are numerous potential predators on juvenile salmonids inhabiting streams and the presence of adequate cover, or shelter, can greatly influence survival rates. Important predators in streams of California's Central Coast include birds such as the belted kingfisher, common merganser, little green heron, great blue heron, and various species of egret; the western aquatic garter snake; and mammals including river otter and raccoon. Instream and overhead cover in the form of undercut banks, tree trunks and branches (whether alive or dead), grasses, herbs, and shrubs, floating or rooted aquatic vegetation, cobbles and boulders, bedrock ledges, and surface turbulence can inhibit the ability of predators to see and capture juvenile salmonids.

The proportion of each habitat unit that was influenced by some type of shelter was estimated as a percentage of the total surface area of the unit. A shelter complexity rating of low, medium, or high was also estimated for each habitat unit based on the areal coverage, structural complexity, and utility of cover present. Percent coverage was generally moderate to low in all reaches of Aptos and Bridge Creeks (Table 6). Percent shelter coverage ranged from 19% to 32% when all habitat types are considered and from 22% to 37% for pool habitats. A relatively high percentage of habitat units were rated as "low" in shelter complexity in the lower 3 reaches of Aptos Creek and in Bridge Creek and the proportion of pools rated as "low" was relatively high in reaches 2, 3, and 4. Even many of the pools that were rated "moderate" in terms of shelter complexity did not have extensive areas of shelter. A high proportion of pools in reaches 2 through 5 and in Bridge Creek had shelter coverage of only 20% or less. Woody debris was present as a cover component in at least a quarter to a third of the pools but was present in nearly two thirds of the pools in Aptos reach 3 and in Bridge Creek.

The most frequently encountered cover types in Aptos Creek were substrate roughness (substrate particles of 5-inch median diameter or greater), a component in 87% of surveyed units, small woody debris (58% of units), and surface turbulence (50% of units) (Table 7, Figure 6). In terms of the areal extent of influence the most extensive cover types included terrestrial vegetation (primarily in reaches 1 and 2) and substrate roughness (more important in the higher gradient, upper watershed reaches). Small woody debris, bedrock ledge, large woody debris, undercut banks, and surface turbulence were present in similar amounts but were distributed differently in different reaches. Bedrock ledges were particularly prevalent in reach 3 and 5. Large woody debris was more extensive in reach 3 than other reaches (Figure 6). In Valencia Creek small woody debris and overhanging terrestrial vegetation were the most prevalent cover types lower in the creek while substrate roughness and surface turbulence became more important in the upper reaches. In pool habitats, small woody debris and overhanging terrestrial vegetation were

Table 5. Habitat Type Summary by Reach

	Aptos Creek						Bridge Creek	Valencia Creek			Trout Creek	Mangels Creek
	A-1	A-2	A-3	A-4	A-5	A-6	B-1	V-1	V-2	V-3	T-1	M-1
	Number of Habitat Units											
Culvert								3			1	1
Flatwater	2	38	22	47	38	46	36	13	36	60	19	
Pool		39	41	42	49	38	22			3	1	
Riffle	1	27	31	28	28	50	45	12	31	54	15	2
LDA					1	14	6	0	13	3	5	3
Lagoon	1											
Dry											2	7
Other								1				1
	Percentage by Length											
Culvert	0%	0%	0%	0%	0%	0%	0%	11%	0%	0%	2%	2%
Flatwater	51%	44%	21%	52%	45%	48%	45%	62%	73%	67%	68%	0%
Pool	0%	42%	61%	36%	38%	18%	9%	0%	0%	1%	0%	0%
Riffle	2%	14%	19%	13%	17%	27%	37%	26%	23%	29%	8%	2%
LDA	0%	0%	0%	0%	0.2%	7%	10%	0%	3%	3%	1%	8%
Lagoon	47%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	21%	83%
Other	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	6%

Notes: cfs – cubic feet per second
ND – not determined
LDA – large debris accumulation

Table 6. Shelter Characteristics by Reach

	Aptos Creek						Bridge C	Valencia Creek			Trout Creek
	A-1		A-3	A-4	A-5	A-6	B-1	V-	V-2	V-3	T-1
Number of units surveyed	4	25	21	21	24	41	21	6	12	16	11
Number of pools surveyed	0	12	12	9	13	17	10	0	0	3	1
Number of units with "high" shelter complexity	0	4	2	0	4	7	2	0	1	0	0
Number of units with "medium" shelter complexity	1	10	12	17	17	28	13	0	4	12	1
Number of units with "low" shelter complexity	3	11	7	4	3	6	6	6	7	4	10
% of all units with "low" shelter complexity	75%	44%	33%	19%	13%	15%	29%	100%	58%	25%	91%
% of pools with "low" shelter complexity		25%	33%	33%	15%	12%	20%	na	na	33%	0%
% pools with 20% or lower shelter coverage		33%	50%	78%	46%	18%	40%	na	na	100%	0%
% pools with large woody debris as cover component		25%	58%	33%	31%	35%	60%	na	na	33%	100%
Average of % Unit with Shelter											
All Habitat Types	19%	29%	30%	23%	30%	32%	25%	6%	16%	21%	4%
Pools	0%	37%	25%	22%	29%	33%	30%	n.a.	n.a.	20%	35%*
Flatwater	5%	24%	32%	22%	35%	34%	22%	5%	16%	17%	2%

Notes: * single pool measured in Trout Creek
n.a. habitat type did not occur in stream reach

Table 7. Aptos Creek Watershed Shelter Components

							Bridge Creek	Valencia Creek			Trout Creek
			A-3	A-4	A-5	A-6	B-1		V	V-3	T-1
Frequency of Occurrence	**Number of Habitat Units**										
Undercut bank	1	11	5	7	2	8	4	4	3	4	2
Small woody debris	2	20	16	10	9	22	10	5	11	12	3
Large woody debris	0	3	10	5	6	13	8	1	5	5	3
Root mass	0	2	2	1	0	3	0	2	0	0	0
Terrestrial vegetation	3	19	7	5	8	9	4	4	7	7	0
Rooted aquatic vegetation	1	2	1	0	0	0	0	2	0	1	0
Floating aquatic vegetation	0	0	0	0	0	0	2	0	0	0	0
Surface turbulence	2	9	8	13	14	22	7	0	4	8	0
Substrate (diameter>5")	2	19	18	21	23	35	17	0	5	10	0
Bedrock ledge	0	6	5	4	11	8	4	1	2	1	1
Other	0	0	0	0	0	0	0	0	0	0	0
Total Surveyed Units	4	25	21	21	24	41	21	6	12	16	11
Areal Extent	**Percent of Total Cover Area**										
Undercut bank	0%	20%	9%	11%	1%	6%	12%	17%	9%	11%	4%
Small woody debris	7%	18%	13%	5%	9%	9%	8%	44%	36%	18%	26%
Large woody debris	0%	7%	21%	8%	8%	12%	15%	3%	20%	10%	64%
Root mass	0%	3%	4%	2%	0%	2%	0%	4%	0%	0%	0%
Terrestrial vegetation	86%	23%	3%	5%	5%	2%	4%	26%	16%	7%	0%
Rooted aquatic vegetation	5%	1%	0%	0%	0%	0%	0%	4%	0%	1%	0%
Floating aquatic vegetation	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Surface turbulence	1%	2%	7%	14%	9%	10%	4%	0%	2%	12%	0%
Substrate (diameter>5")	1%	16%	21%	45%	49%	54%	47%	0%	16%	36%	0%
Bedrock ledge	0%	10%	22%	10%	18%	5%	9%	2%	1%	5%	6%
Other	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

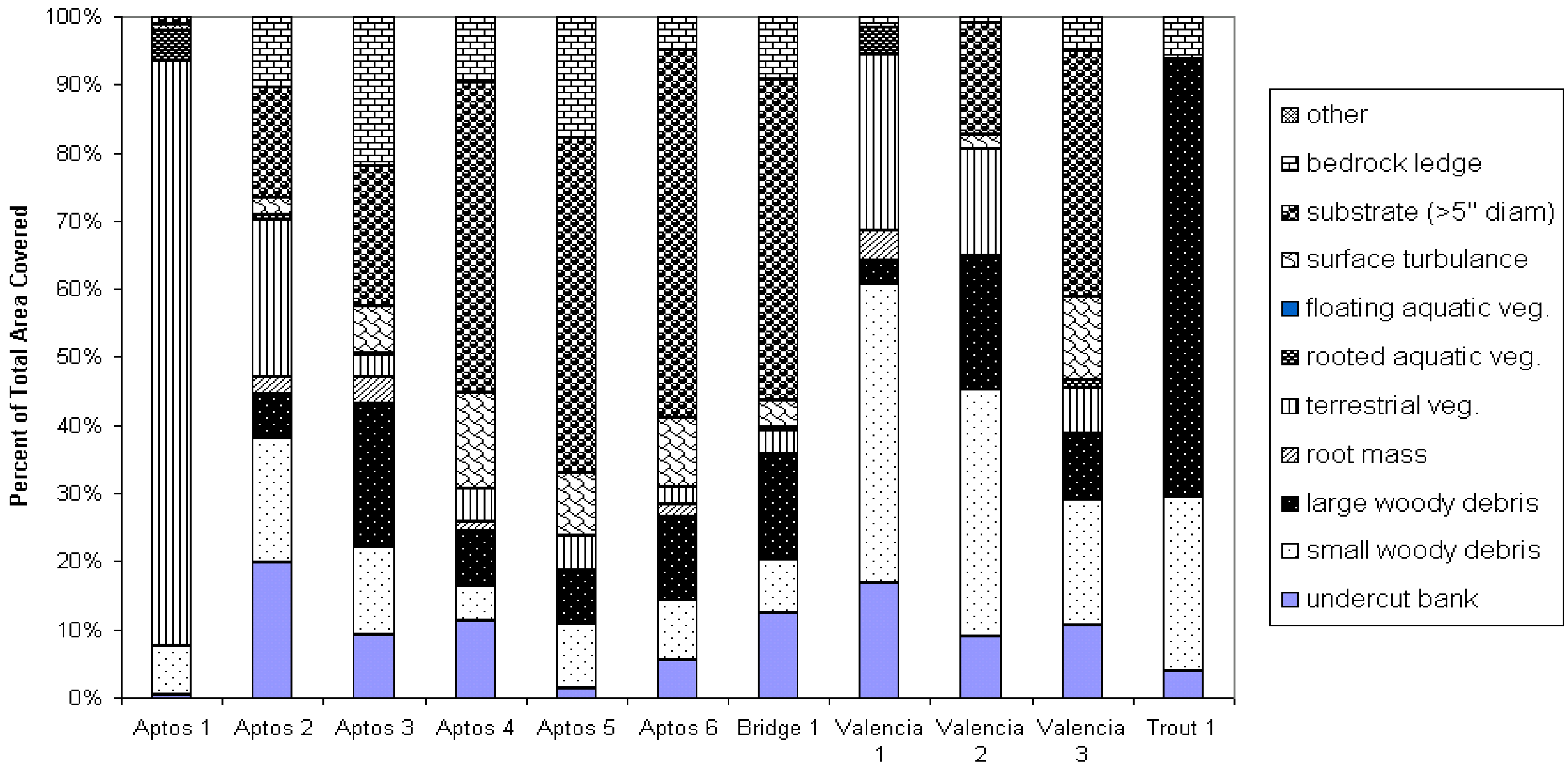


Figure 6. Shelter Components for all Habitat Types

common in the lower part of Aptos Creek while bedrock ledge, substrate roughness, and large woody debris were dominant in the upper reaches (Figure 7).

3.2.3 Substrate Condition

Substrate conditions influence spawning and egg incubation, cover for juveniles, and production of aquatic invertebrates important in the aquatic food chain. Steelhead and coho salmon rely on relatively loose, clean gravel substrate with low amounts of fine sediments for reproduction. Larger substrate such as cobbles and boulders can provide hiding areas for juveniles of many species including trout. Fine sediments (silt and sand) present in excessive amounts fill spaces between the larger substrate elements and reduce its ability to support invertebrate production, spawning, and escape cover. A number of criteria are used to describe substrate mixtures occurring in streams and assess suitability for different life stages of anadromous salmonids (Kondolf 2000). The most detailed methods involve bulk sampling of the streambed and characterization of the complete range of sediment size classes. A simpler method, and one that is more appropriate for basin-wide assessment level surveys, involves estimating cobble embeddedness. This is accomplished in habitat surveys by observing the average proportion of individual cobble size substrate that is embedded in finer material. Embeddedness is estimated both in pool tails and in other areas with suitable conditions for spawning. Fish density, particularly for juvenile trout and salmon, is generally reduced as embeddedness increases. Steelhead appear to be less sensitive than some other salmonid species. Young-of-year fish are particularly sensitive during winter and can be impacted at embeddedness levels greater than 5%-10%. Older juveniles during summer may tolerate embeddedness levels of 30%-50% without significant impacts on population density. Excessive amounts of fine sediment may also fill in pools and other deep areas and reduce their utility as habitat for adult fish.

Habitat conditions in Aptos and Bridge Creeks were influenced by high levels of sand in the substrate (Figure 8). Sand was the dominant substrate in 59% to 70% of habitat units in reaches 2 through 6 and was dominant in all units in reach 1 (downstream of the Valencia Creek confluence). Sand was the subdominant substrate in an additional 10% to 17% of habitat units in reaches 4, 5, and 6 (Figure 9). In Bridge Creek, sand was the dominant substrate in 95% of habitat units and subdominant in the other 5%.

Riffles provide important habitat for production of aquatic invertebrates and salmonid spawning areas are typically located near the head of riffles. High amounts of sand impairs both these functions. In Aptos Creek riffle habitats, sand was still the dominant substrate in reach 1, half the units in reach 2, and two-thirds of the units in Bridge Creek (Figure 10). Sand was the subdominant component in 17% to 30% of riffle habitat units in reaches 4, 5, and 6 of Aptos Creek (Figure 11). In Bridge Creek, sand was the dominant substrate in 2 of 3 riffles surveyed and was subdominant in the third.

Valencia Creek was even more heavily influenced by sand than Aptos Creek (Figure 12). Sand was the dominant substrate in 100% of habitat units in the two lower reaches (Aptos Creek to Valencia Road). Sand was also dominant in 94% of the habitat units in reach 3 (upstream of Valencia Road). As a result, there were no pools in reaches 1 and 2 and pools made up slightly less than 1% of the length of reach 3. Gravel and cobble substrate were present as dominant substrates only in reach 3, where these classes were dominant in 6% of all units and 20% of riffle units. Even in reach 3 of Valencia Creek, sand was either dominant or subdominant in 80% of the habitat units.

Trout Creek was less dominated by sand substrate than Valencia Creek but sand was still the dominant substrate in over 70% of all surveyed units and was dominant in 60% of surveyed riffle habitats. Small cobble was the dominant size class most in units where sand was not dominant.

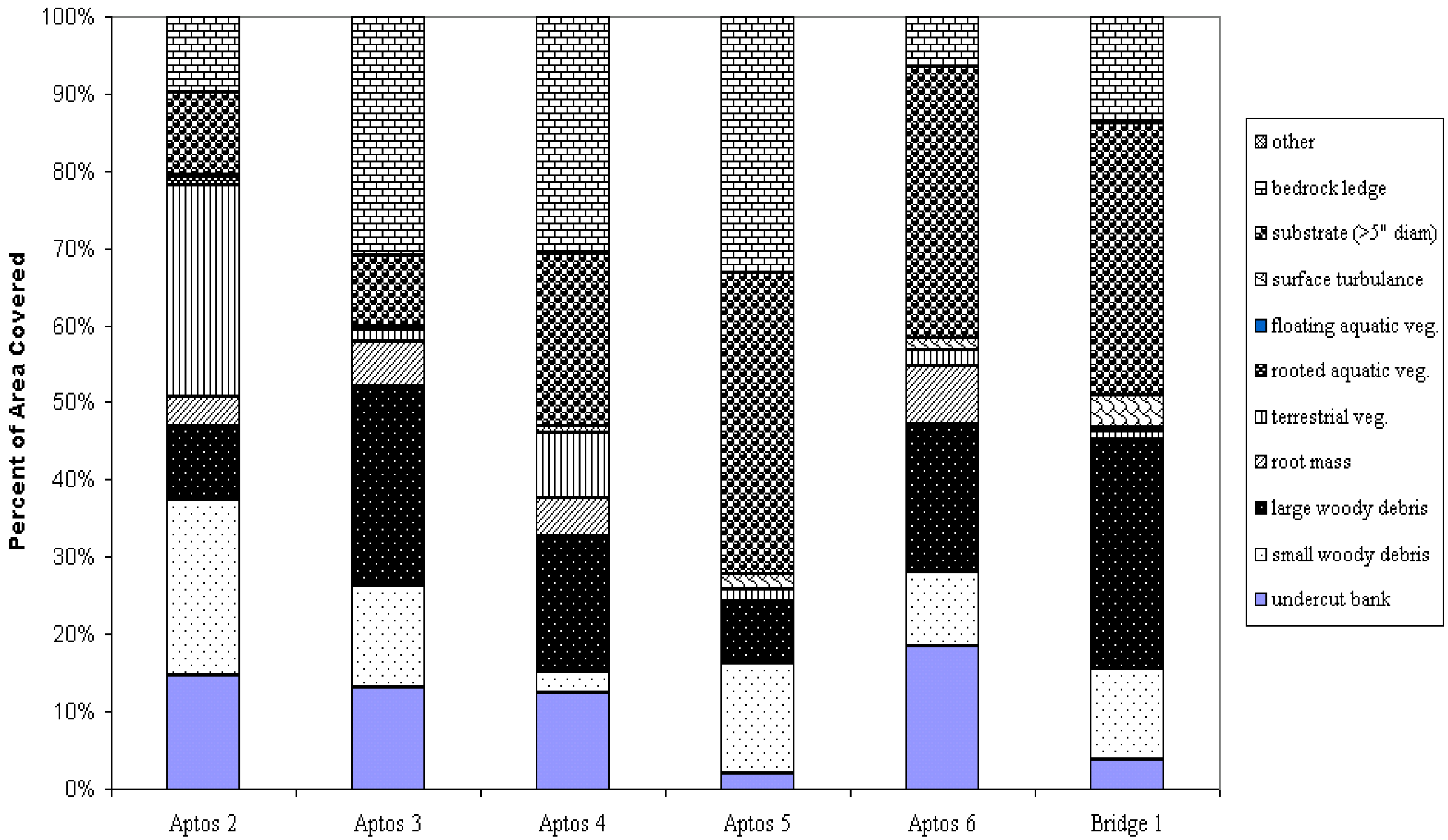


Figure 7. Shelter Components for Pool Habitat Types

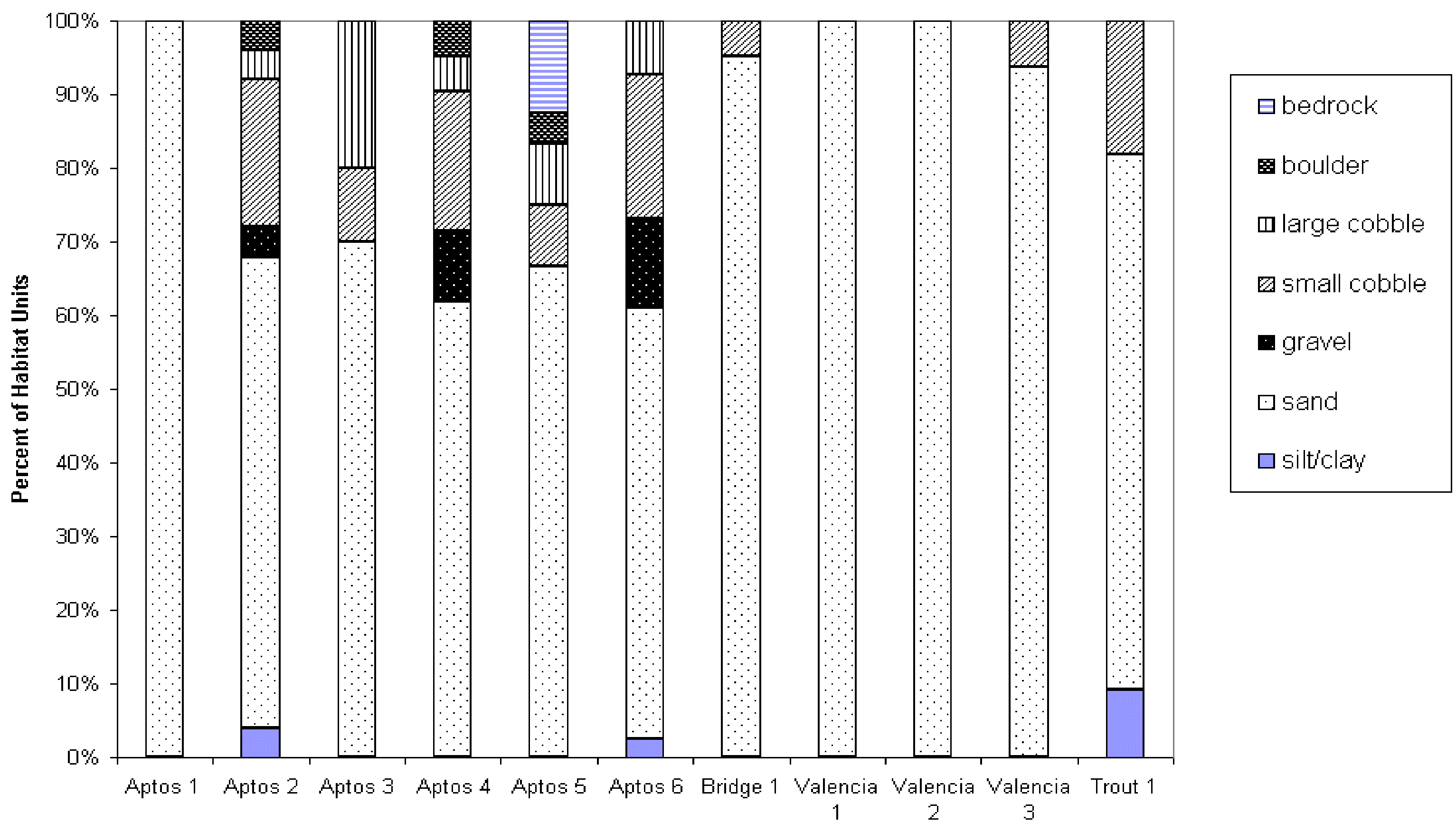


Figure 8. Dominant Substrate Composition

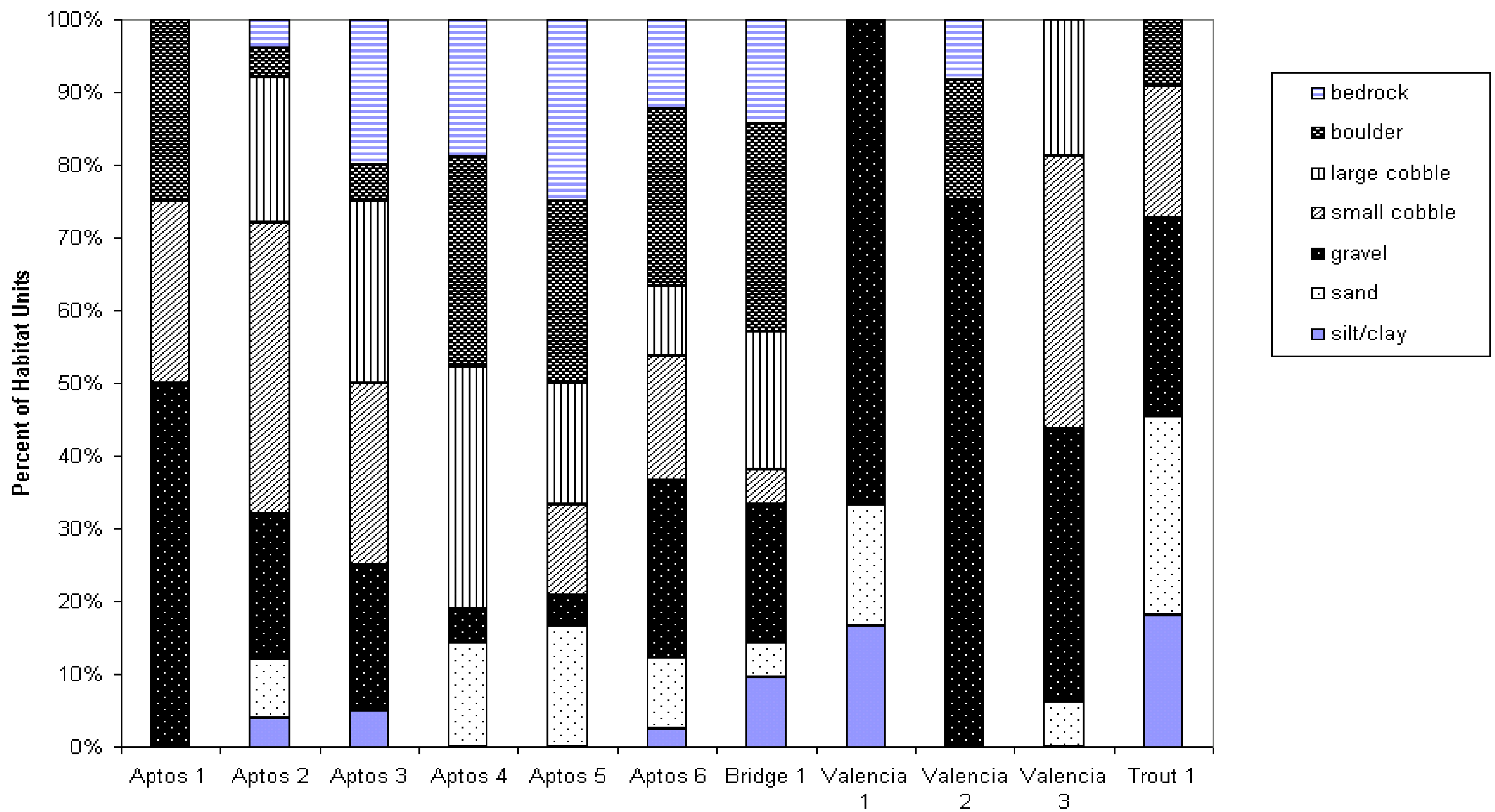


Figure 9. Subdominant Substrate Composition

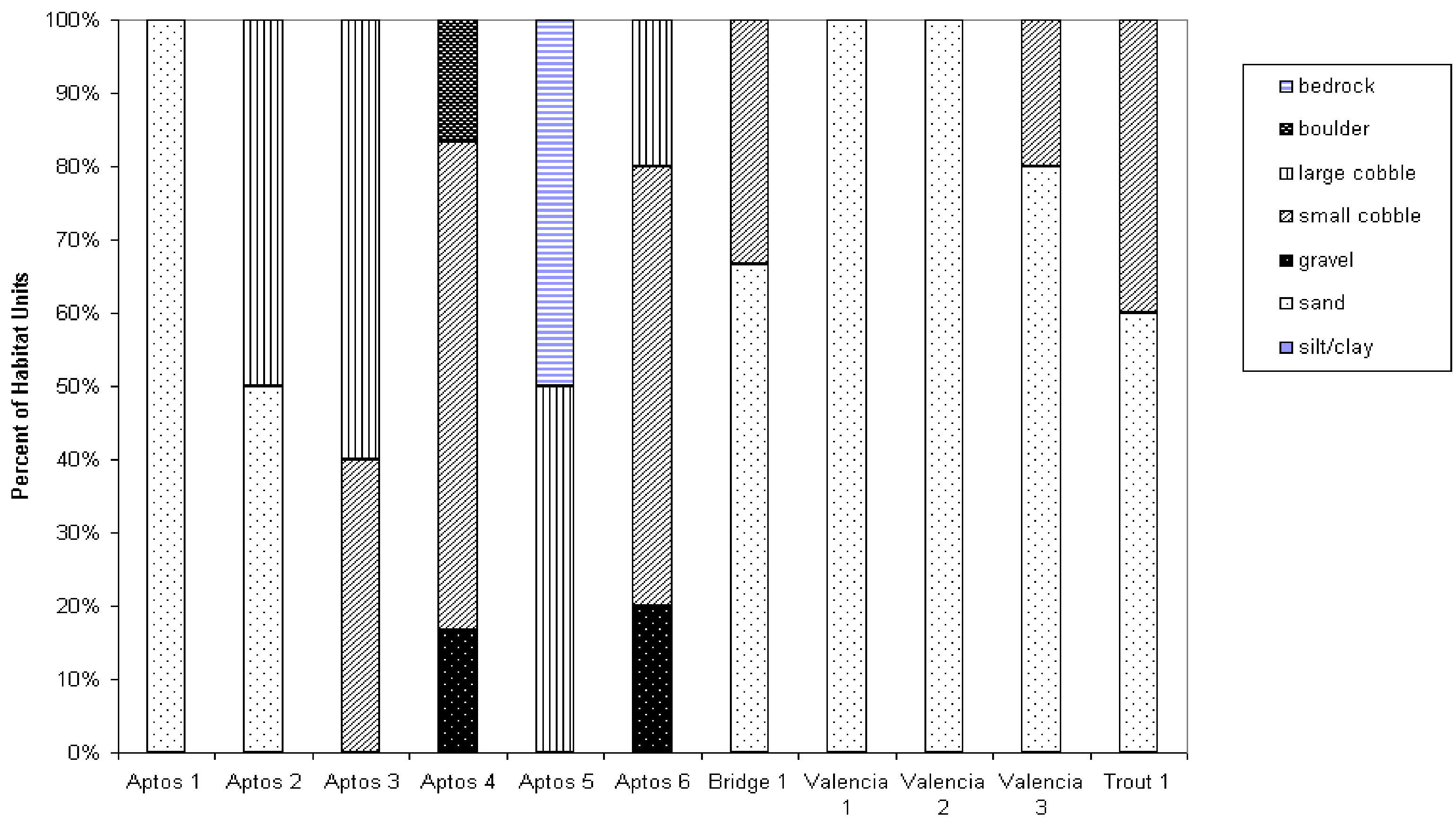


Figure 10. Dominant Substrate in Riffle Habitats

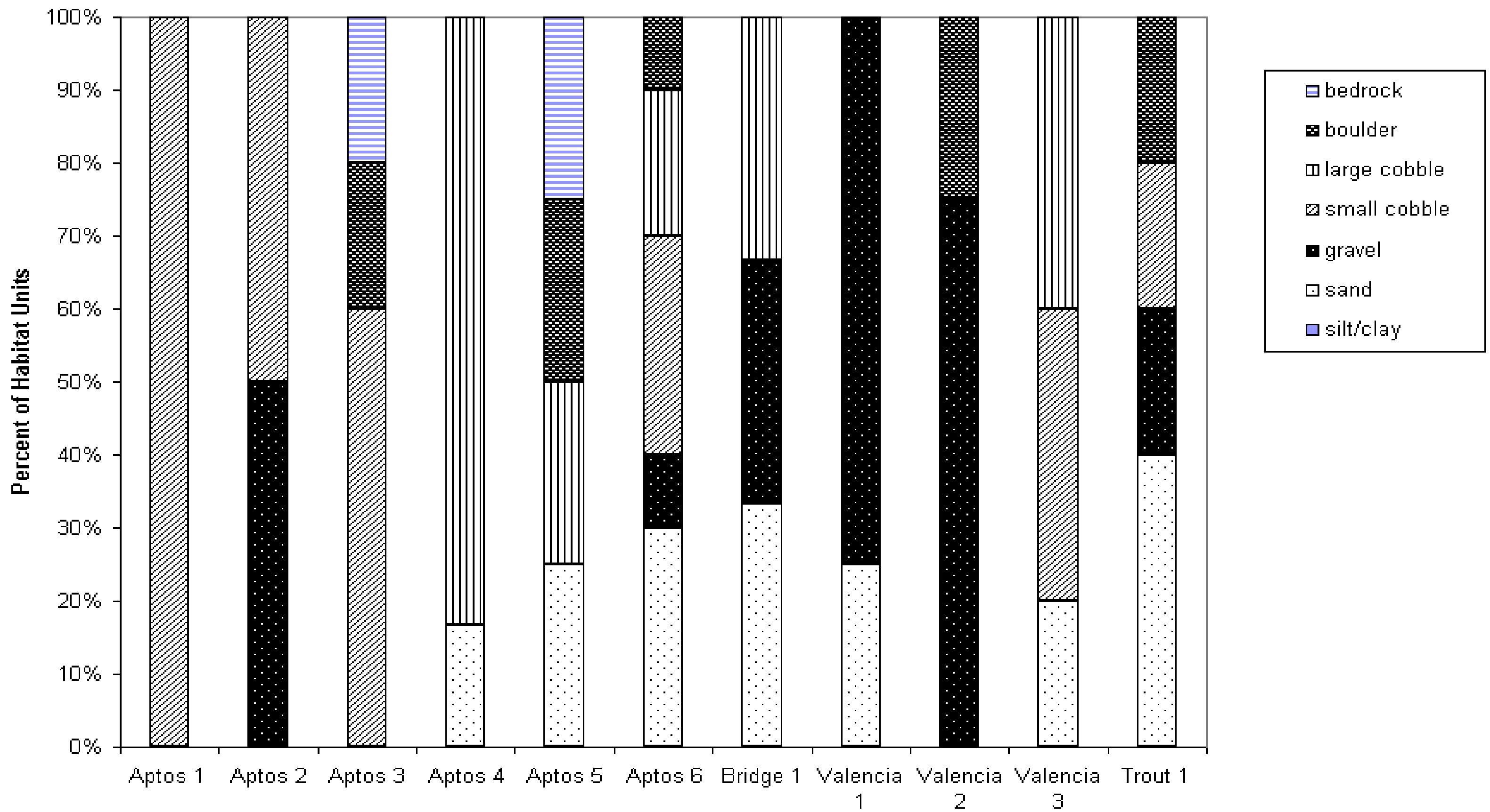


Figure 11. Subdominant Substrate in Riffle Areas

Figure 12. Riffle/Glide Habitat in Valencia Creek

Gravel was present only as a subdominant size class and was never estimated at more than 5% in any habitat unit.

Areas with suitable substrate and hydraulic conditions for spawning were relatively scarce throughout the watershed (Table 8). In Aptos Creek, reach 4 had the greatest concentration of spawning areas although reaches 2, 3, and 5 also had some areas with good spawning conditions. The low frequency of suitable spawning areas resulted primarily from high levels of sand in the substrate.

The presence of large quantities of sand was evident in the embeddedness data. In Aptos Creek, over 50% of all pool tails had embeddedness of more than 30% in reaches 2, 3, and 4 (Figure 13). Embeddedness was lower in reaches 5 and 6 with, respectively, only 36% and 33% of sampled units having embeddedness greater than 30% (Table 8). Reaches 5 and 6 also had the highest percentage of units with relatively low embeddedness ratings of 15% or lower (28% and 41% of units, respectively). In Bridge Creek, 60% of units had embeddedness of more than 30% while only 10% had embeddedness of 15% or lower. For those areas judged to provide the best conditions for spawning, embeddedness ratings were generally better than in pool tails as a group (Figure 14). The least embedded spawning areas were in reach 5 where 75% of all potential spawning areas had embeddedness of 15% or less. Only about a third of the spawning areas identified in reaches 4 and 6 had embeddedness of 15% or less. Reaches 2 and 3 also had some spawning areas with relatively low embeddedness. Although the amount of potential spawning area identified in Bridge Creek was very small (2 areas totaling only 23 square feet), embeddedness was low.

In Valencia Creek, pools were present only in reach 3, where 2 of the 3 pool tails assessed had embeddedness ratings of 30% or greater. Also, due to extensive sand substrate, areas with suitable conditions for spawning were not identified in reach 1 of Valencia Creek and were extremely limited in reaches 2 and 3. Where present, potential spawning substrate had relatively low embeddedness with the majority of areas having 15% or lower embeddedness and no areas having embeddedness greater than 50%.

No embeddedness estimates were made in Trout Creek. Embeddedness was not measured in the single pool since it was a backwater pool without a tail typical of main channel pools. There were no sites identified in the entire reach that had potential as spawning sites.

3.2.4 Bank and Canopy

Vegetation on the stream bank is intricately linked to the aquatic environment and influences it in many ways. Vegetation provides shade and moderates temperature conditions. This vegetation also serves as an important source of nutrients to the stream, both through direct input of organic matter and as a source of terrestrial insects. Aquatic productivity can be inhibited under conditions of continuous closed canopy, and the ideal condition is a moderately dense canopy (55%-85%) with occasional small openings. Terrestrial environments near the stream provide important habitat for amphibians such as frogs, salamanders, newts and reptiles such as turtles and snakes. The roots of riparian species such as alder, willow, sycamore, and redwood form networks that strengthen and retain the bank and lead to formation of scour pools and undercut banks that provide excellent instream cover for fish. As these trees age they may eventually fall into the stream and their trunks and branches alter flow patterns and provide hard structures resulting in scouring of pools. Terrestrial vegetation hanging over the stream bank also can provide useful overhead cover for fish. Basic information for canopy and riparian vegetation is provided here. More detailed information can be found in the companion Technical Memorandum describing the Riparian Overstory Description and Mapping Task.

Table 8. Substrate Characteristics by Reach

	Aptos Creek						Bridge Creek	Valencia Creek			Trout Creek
	Aptos Creek A-1	Aptos Creek A-2	Aptos Creek A-3	Aptos Creek A-4	Aptos Creek A-5	Aptos Creek A-6	Bridge Creek B-1	Valencia Creek V-1	Valencia Creek V-2	Valencia Creek V-3	Trout Creek T-1
Areas with Spawning Gravel Surveyed	0	13	9	21	16	13	2	0	4	2	0
Spawning Gravel Area (square feet)	0	260	252	455	213	138	23	0	14	7	0
Spawning Area (square feet) per 100 feet	0.0	3.6	3.0	4.4	2.3	1.7	0.4	0	0.1	0.1	0
Average spawning site size (square feet)	0	20	28	22	13	11	12	0	3.5	3.5	0
Pool Tail Embeddedness (%)	**Number of Habitat Units**										
0-15%	n.a.	8%	0%	14%	28%	41%	10%	n.a.	n.a.		n.a.
16-30%	n.a.	41%	46%	30%	36%	27%	30%	n.a.	n.a.	100%	n.a.
31-50%	n.a.	30%	49%	47%	32%	19%	40%	n.a.	n.a.		n.a.
>50%	n.a.	22%	5%	9%	4%	14%	20%	n.a.	n.a.		n.a.
Number of Pools Surveyed	0	37	39	43	47	37	20	0	0	3	0
Spawning gravel embeddedness (%)	**Number of Habitat Units**										
0-15%	n.a.	23%	11%	33%	75%	31%	100%	n.a.	75%	50%	n.a.
16-30%	n.a.	69%	89%	52%	25%	46%	0%	n.a.	25%	50%	n.a.
31-50%	n.a.	8%	0%	14%	0%	15%	0%	n.a.	0%	0%	n.a.
>50%	n.a.	0%	0%	0%	0%	8%	0%	n.a.	0%	0%	n.a.

Notes: n.a.: no pools or no spawning areas occurring in stream reach

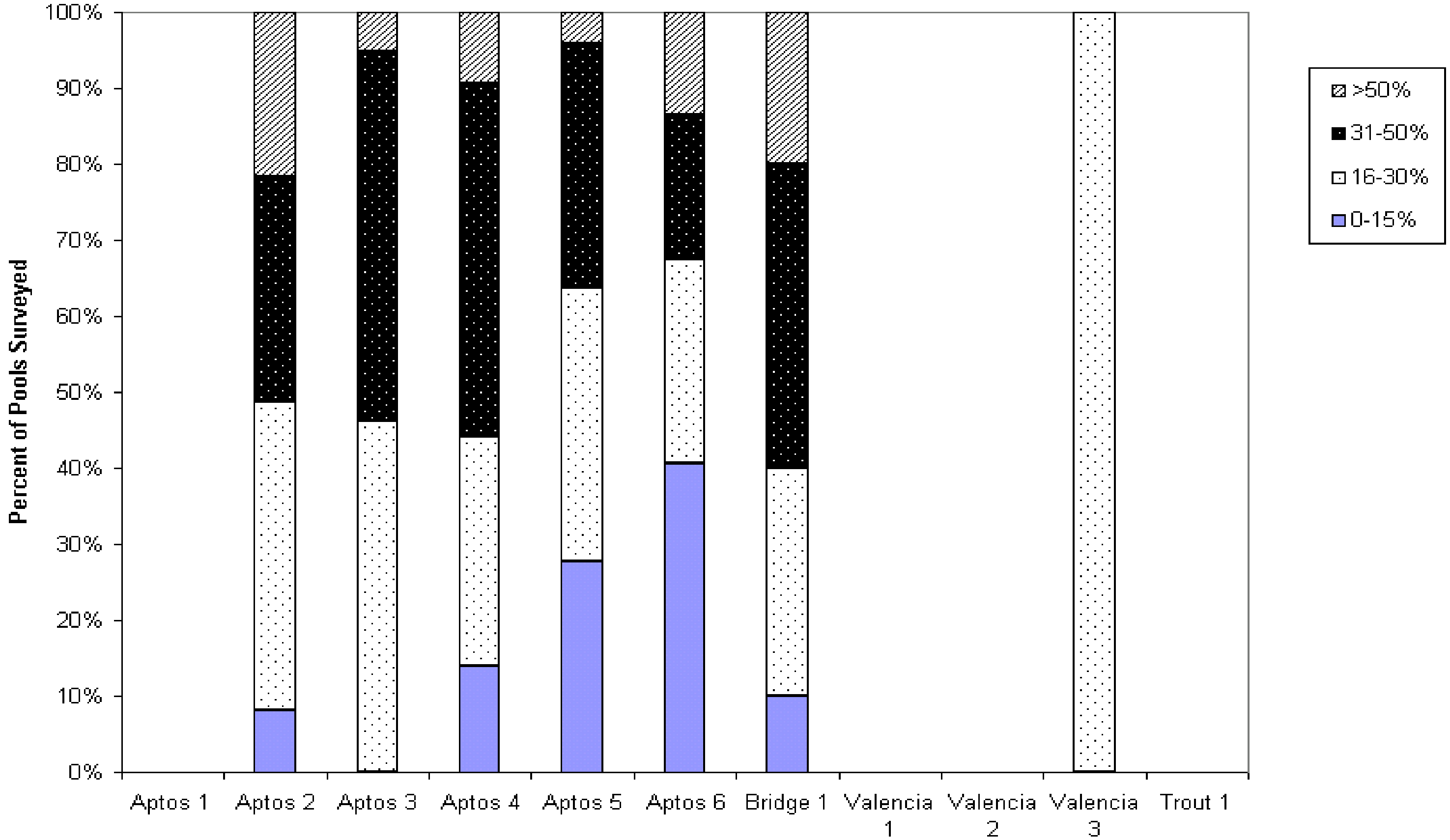


Figure 13. Pool Tail Embeddedness Ratings

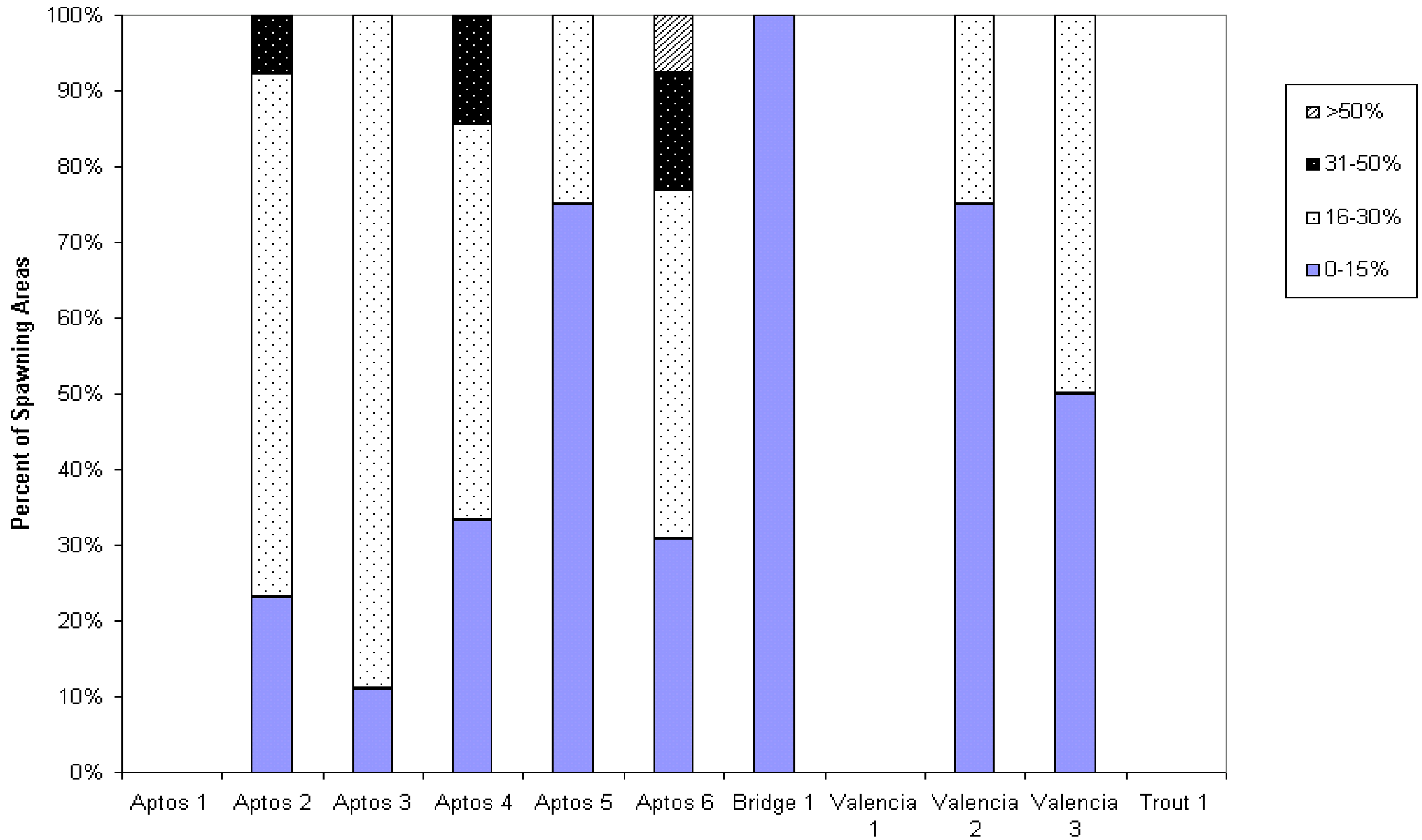


Figure 14. Spawning Area Embeddedness Ratings

Canopy was highly variable in Aptos and Bridge Creeks, ranging from 10% or less to 95% or more in each reach. No clear differences between reaches were distinguishable (Table 9). Valencia Creek had higher levels of canopy closure than Aptos and Bridge Creeks. Average canopy coverage was generally at least 60%. Habitat units with relatively open canopies were fairly well dispersed through the watershed. A more open canopy can enhance aquatic productivity and trout growth rates as long as associated temperature increase is not extreme. Most stream reaches have a generally north-south orientation, which together with topographic shading from the steep terrain, minimizes direct solar radiation.

Alder was the dominant canopy species in 50% of the habitat units in Aptos Creek and was the subdominant species in an additional 26% of habitat units (Table 9). Alder was less dominant with distance upstream in Aptos Creek and was rarely dominant in Bridge Creek. Maple, redwood, tan oak, and willow became more often dominant in upper reaches of Aptos Creek. Large woody debris was a dominant canopy component in a few units in reach 6. Redwood was the dominant species in 76% of habitat units in Bridge Creek, with maple, tan oak, and alder dominant in most of the remaining units. Alder was also the most common dominant species in Valencia Creek. Box Elder was also a common dominant species in lower Valencia Creek. Trout Creek had redwood and maple as the most common dominant species and two species, blackberry and oak, appeared as dominant species in Trout Creek but nowhere else.

3.2.5 Temperature

Temperature determines the distribution of many native fish species and of salmonids in particular. Stream temperature generally fluctuates on a daily basis in parallel with air temperature and reaches maximum levels in streams of Central California in July and August. Temperature becomes lethal for both steelhead and coho as it approaches and exceeds about 25°C (77°F). Though there is much variation, temperatures below 18°C (64°F) are generally regarded as optimum for rearing steelhead although temperatures up to 21°C (70°F) may be suitable if food is sufficiently abundant. For coho salmon, optimum temperature is commonly cited in the range of 11°C to 15°C (52°F-59°F) and extended periods with temperatures exceeding 18°C (64°F) may significantly limit coho populations.

Temperature monitoring was not conducted as part of this study. Temperature grab samples ranged from 13°C to 15°C (55°F-59°F) in Aptos Creek during surveys in late August, and 12°C to 15°C (54°F-59°F) in Valencia Creek in early October (air temperature ranged up to 20.5°C (69°F) in August and 23°C (73°F) in October). Temperature data have been collected by Coastal Watershed Council and CDFG during 1999 and 2000. These data indicate that peak temperature in Aptos Creek almost never exceeds 18°C (65°F). Temperature monitoring by CDFG in 1999 (Nelson, 2000) indicated temperatures in Aptos Creek near George's Picnic Area exceeded 15°C (55°F) 36% of the time between July 22 and November but never exceeded 17.8°C (64.1°F). At a more upstream monitoring location temperature exceeded 15°C (59°F) 55% of the time with a maximum of 18.9°C (66.1°F). Data collected by CDFG indicate that temperature conditions in Aptos Creek in 1999 were comparable to other Central Coast streams supporting coho salmon including Waddell Creek and Scott Creek.

3.2.6 Barriers to Fish Movement

Full levels of production for anadromous salmonids in Central California coastal streams relies on the ability of adult steelhead to enter the streams and easily access spawning and rearing habitat in the upper reaches and for smolts to return to the ocean. Even obstacles that are not complete barriers can impair populations by delaying migration rates and exposing fish to potential predation or poaching. Instream movement of rearing juveniles may also be important.

Table 9. Canopy Characteristics by Reach

	Aptos Creek						Bridge Creek	Valencia Creek			Trout Creek
	A-1	A-2			A-5		B-1	V-1	V-2		T-1
Average canopy (percent)	68%	60%	61%	67%	56%	64%	48%	70%	70%	72%	66%
Maximum canopy (percent)	90%	95%	95%	95%	95%	95%	98%	85%	95%	95%	95%
Minimum canopy (percent)	50%	5%	0%	10%	10%	5%	5%	45%	25%	10%	0%
% of units with 55-85% canopy	50%	40%	41%	42%	47%	46%	36%	82%	64%	48%	47%
Dominant Canopy Species	**Number of Habitat Units**										
Alder	3	33	20	29	17	30	2	8	9	19	3
Blackberry	0	0	0	0	0	0	0	0	0	0	1
Box elder	0	0	0	0	0	0	0	2	1	0	0
Dogwood	0	1	0	0	0	0	0	0	0	0	0
Large woody debris	0	1	2	0	3	8	2	0	2	1	0
Maple	0	3	5	6	8	17	3	0	8	6	4
Oak	0	0	0	0	0	0	0	0	0	0	2
Redwood	0	2	4	5	12	9	38	0	7	10	7
Sycamore	0	1	0	0	0	0	0	0	0	0	0
Tan oak	0	1	8	8	11	4	3	1	6	9	1
Willow	1	6	1	0	0	4	1	0	1	1	0
Witch hazel	0	0	0	0	0	0	1	0	0	0	0
Total Surveyed Units	4	48	40	48	51	72	50	11	34	46	18

Rearing juveniles need to disperse from spawning areas to rearing habitat. Young trout prefer shallower glide and riffle areas in or near relatively swift current but as they mature they move to deeper habitats. In some streams, seasonal movement may be important to avoid sections that go dry during summer months. Extreme events may eliminate fish from sections of stream. During droughts some sections may go dry. Individuals may move into small tributaries or to lower gradient reaches during extreme high flows. Episodes of poor water quality conditions may eliminate fish from a section of stream. In these cases dispersal from refuge areas is required to re-populate the stream. If the only refuge areas are downstream, barriers may result in failure of re-colonization and loss of fish populations from otherwise suitable habitat upstream. The following sections detail migration obstacles in each of the surveyed stream reaches.

3.2.6.1 Aptos Creek Mainstem

There are no significant obstacles to migration of adult steelhead and coho salmon in the lower five reaches of Aptos Creek, although there are three locations where adult upstream migration may be impaired at lower levels of flow (Table 10, Figure 15). The first of these is immediately upstream of Spreckels Road and consists of a concrete weir spanning the creek (Figure 16). At the time of the survey the weir rose about 1.5 feet above the downstream water surface with a relatively shallow depth of flow up to about 1 foot deep immediately downstream of the weir. It is expected that the loose sand substrate would be scoured out from below the weir at higher flows, forming a deeper pool from which fish could leap over the weir. This condition was observed on December 12, 2001 when a pool up to 4 feet deep had been scoured below the weir. In addition, observations on October 1, 2001 indicated that at higher lagoon stages (0.85 on SH&G lagoon staff gage), the water surface backs up over the weir and eliminates any barrier effect (photos available). Upstream of the weir the sandy channel is wide and uniformly shallow for a long distance upstream (a few hundred feet).

The other two locations in Aptos Creek, reaches 1-5, where adult passage may be impaired are caused by accumulations of large woody debris (LDAs) and these did not appear to present significant obstacles to passage of healthy adult steelhead or coho. The first had an elevation change of only about 2.5 feet and at higher flows this would be reduced. An unobstructed side channel was also available that would likely provide passage at higher flows. The second LDA had a more substantial elevation change of about 5.5 feet but there was relatively good flow under the debris and adults would likely be able to pass through the jam at moderate flows.

Upstream of Reach 5, LDAs increase in frequency (Figure 15). Some of these accumulations likely shift under varying flow conditions and may become more or less of an obstacle at different times. They are also transient in that new accumulations form and old ones break up over time although the lifespan of any given LDA is not known. It is very difficult to be sure whether these debris accumulations form a barrier to migration or under what flow conditions a given LDA may become passable (Figure 17). Due to the increasing frequency of LDAs, we believe that the upper limit of anadromy in Aptos Creek is somewhere within Reach 6 and possibly is quite low in the reach. The first LDA encountered, at the break from reach 5 to reach 6 appeared to be a relatively significant obstacle at the time of the survey. It had an overall drop of about 6 feet without apparent passage through any side channel. Although a migrating adult may be able to pass some of these obstacles, or pass many of them under ideal flow conditions, their cumulative effect is likely to severely limit the frequency of access to upper parts of the reach and reduce the number of individuals that can successfully pass. It is perhaps significant that the density of young-of-year steelhead dropped off fairly sharply after the first significant LDA, at the break between reach 5 and 6 (Figure 18).

Table 10. Potential Migration Barriers

Stream Reach	Location	Survey Date	Habitat Unit Number	Survey Distance (feet)	Photo #	Type	Barrier Degree Adult	Degree Upstream Juvenile
A-1	N 36° 58.414" W 121° 54.226'	28-Aug-01	2	1012	7	Weir	Low Flow	Most Flows
A-3	N 36° 59.378" W 121° 54.462'	27-Aug-01	107	9420	18	LDA	Low Flow	Most Flows
A-5	N 37° 01.908' W 121° 53.453'	30-Aug-01	396	34324	24,1	LDA	Low Flow	No Obstruction
A-5	N 37° 01.876' W 121° 53.315'	30-Aug-01	410	35486	2	LDA	Most Flows	Near Complete
A-6		30-Aug-01	414	35699		LDA	Low Flow	Low Flow
A-6	N 37° 01.848' W 121° 53.175'	30-Aug-01	426	36260	3	LDA	Undetermined	Undetermined
A-6	N 37° 01.851' W 121° 53.000'	30-Aug-01	438	37235	4	LDA	Low Flow	No Obstruction
A-6	N 37° 01.841' W 121° 53.023'	3-Oct-01	439	37257		LDA	No Obstruction	No Obstruction
A-6		3-Oct-01	470	39350	21	LDA	Low Flow	No Obstruction
A-6	N 37° 02.070' W 121° 52.691'	3-Oct-01	478	39724	23,24	LDA	Near Complete	Near Complete
A-6		7-Oct-01	484	40220		LDA	Low Flow	Low Flow
A-6		7-Oct-01	518	41699	3	LDA	Low Flow	Low Flow
A-6	N 37° 02.411' W 121° 52.291'	7-Oct-01	520	41767	4	LDA	Low Flow	Low Flow
A-6		7-Oct-01	522	41891	5	LDA	Low Flow	Most Flows
A-6		7-Oct-01	544	42936	6	Cascade	Most Flows	Most Flows
A-6	N 37° 02.622' W 121° 52.156'	7-Oct-01	554	43356		LDA	Most Flows	Near Complete

Table 10. Potential Migration Barriers (continued)

Stream Reach	Location	Survey Date	Habitat Unit Number	Survey Distance (feet)	Photo #	Type	Barrier Degree Adult	Degree Upstream Juvenile
B-1	N 37° 01.860' W 121° 54.095'	5-Oct-01	11	711	12,13	LDA	Low Flow	Most Flows
B-1		5-Oct-01	24	1,544	15,16	LDA	Most Flows	Most Flows
B-1		5-Oct-01	33	1,895	17	Cascade	Low Flow	Most Flows
B-1		5-Oct-01	40	2,203	18	Cascade	Low Flow	Most Flows
B-1		5-Oct-01	74	3,778	22	LDA	Complete	Complete
V-1		1-Oct-01	2	70	3,4,5	Culvert	Low Flow	Low Flow
V-1		1-Oct-01	6	1108	7,8	Culvert	Low Flow	Low Flow
V-1		1-Oct-01	8	1512	9,10,11	Culvert	Most Flows	Most Flows
V-2		1-Oct-01	2	5724	18	Cascade	Low Flow	Most Flows
V-2	N 36° 58.733' W 122° 53.116'	1-Oct-01	7	6818	21	LDA	Low Flow	Most Flows
V-2	N 36° 58.900' W 121° 52.693'	1-Oct-01	28	10405	3	LDA	Low Flow	Most Flows
V-3	N 36° 59.881' W 121° 52.142'	2-Oct-01	1	20577	8,9	Culvert	Low Flow	Low Flow
V-3	N 37° 00.739' W 121° 52.457'	2-Oct-01	84	26883	14	LDA	most Flows/complete	Most Flows/complete
M-1		4-Oct-01	4/5	679	6		Complete	Complete
M-1	N 36° 58.971' W 121° 54.093'	4-Oct-01	11	1190	9		Complete	Complete

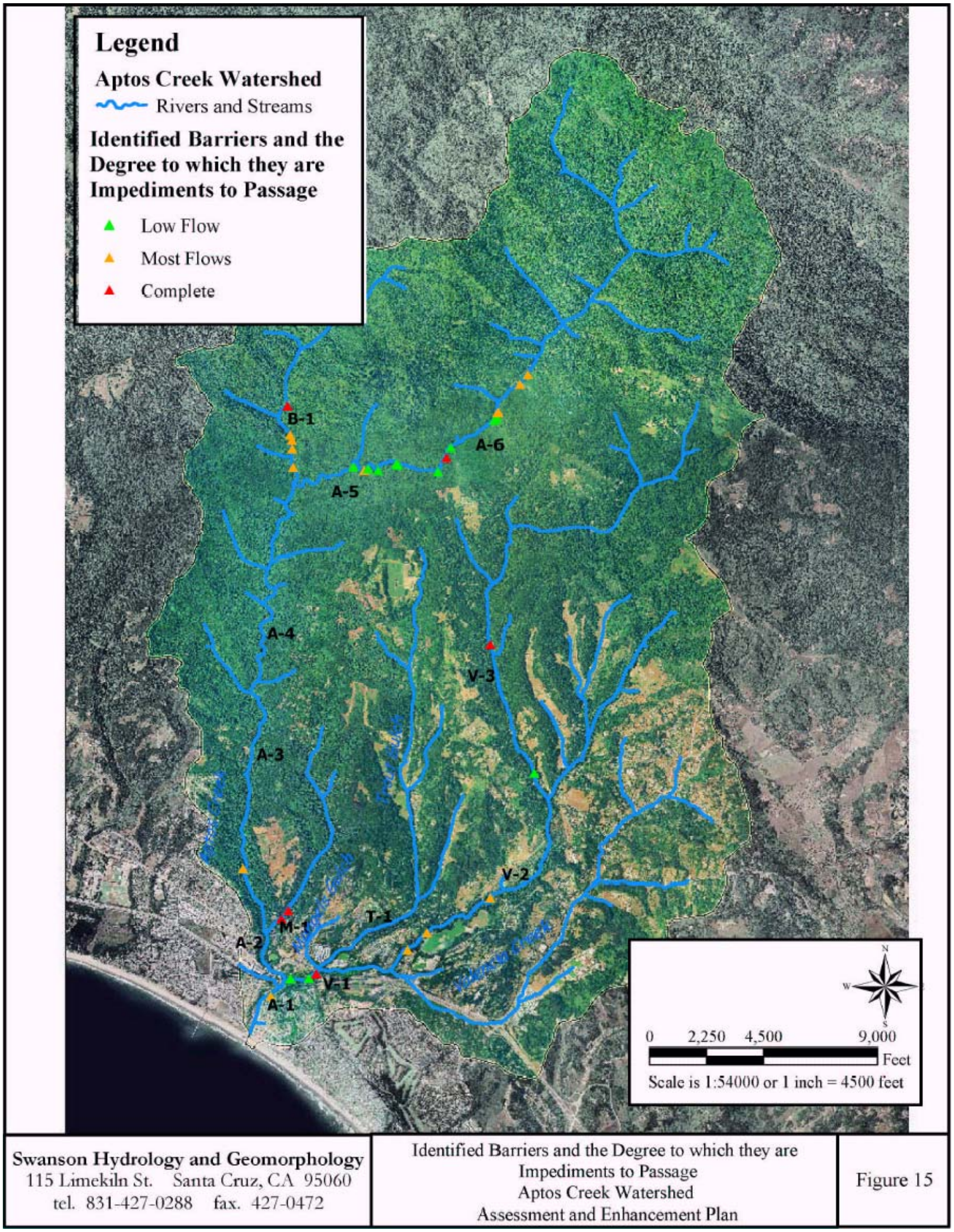


Figure 15. Identified Passage Barriers

Figure 16. Weir at Spreckels Road

Figure 17. Large Debris Accumulation (LDA), Upper Aptos Creek

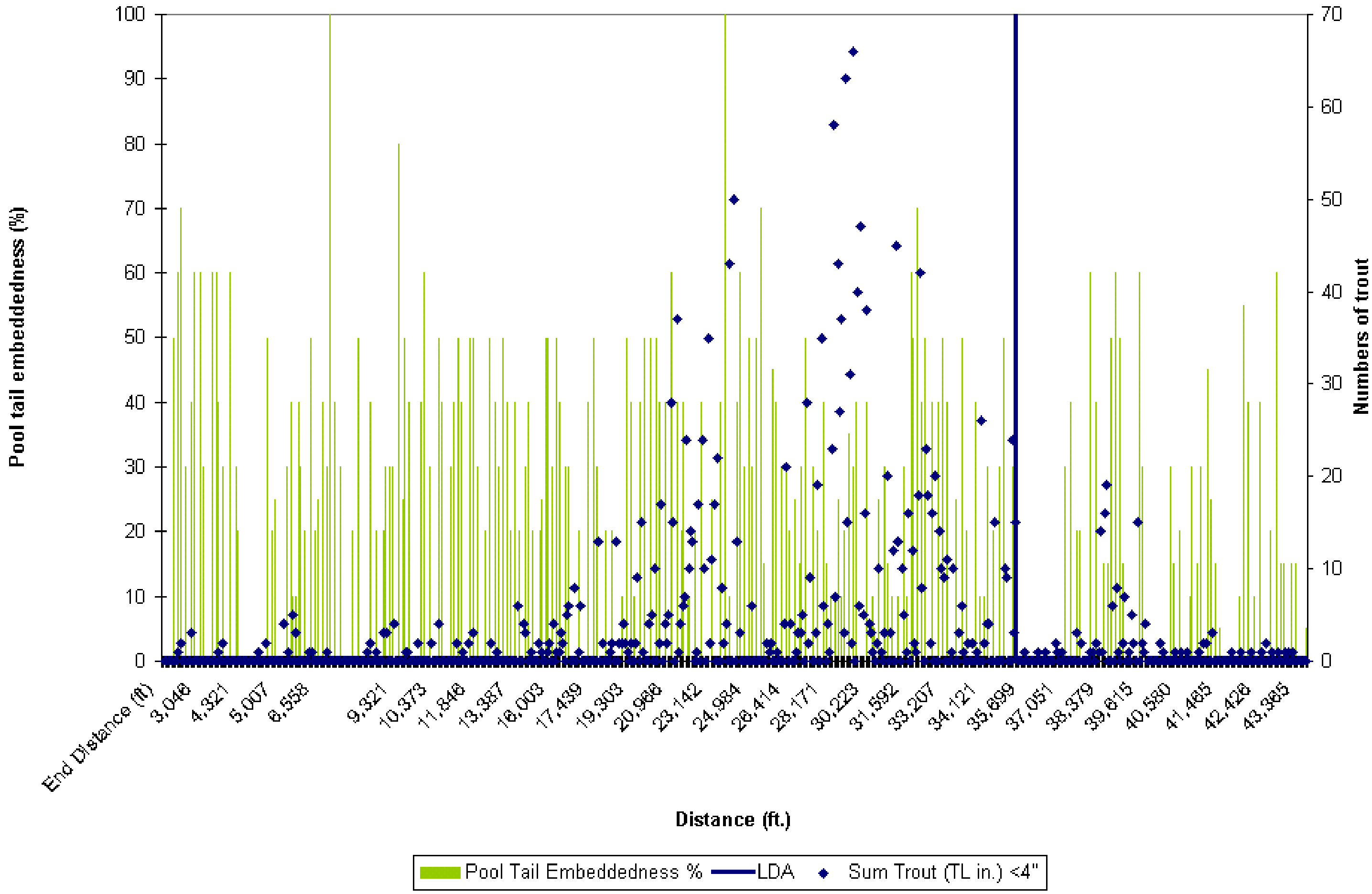


Figure 18. Aptos Creek Pool Tail Embeddedness and Distance

3.2.6.2 *Bridge Creek*

There were a total of 5 passage obstacles in the lower 3/4 mile of Bridge Creek. The first four, two LDAs and two cascades, were likely only obstacles to passage of adult steelhead or coho during low flow conditions. The last, an LDA, was judged to be a complete barrier for upstream migration of both adults and juveniles. This final LDA had a drop of about 6 feet with sediment filling the upstream channel and no jump pool below. There was no flow through the LDA at the time of the survey as the entire flow of the creek (estimated at 0.5 cfs to 1.5 cfs) seeped into the sediment accumulated upstream. This barrier was located about 3,778 feet (0.72 mile) upstream from the Aptos Creek confluence. Juvenile trout were seen up to the barrier but none were seen upstream of it. Also of interest, Pacific giant salamander were not seen below this barrier but became common immediately upstream. On the other hand, foothill yellow-legged frog were seen both above and below this point.

3.2.6.3 *Valencia Creek Mainstem*

A total of eight passage obstacles were identified in Valencia Creek, four of which were culverts (Table 10). The first three obstacles, all culverts, occurred within the lower quarter mile of the Creek. The first two culverts presented low to moderate passage difficulty (Figure 19). They were about 240 feet and 180 feet in length, 10 feet in width, and had gradients between 1% and 2%. Both were fitted with a baffle system on one side, presumably to aid fish passage, but most of the baffle sections had filled with sediment and debris, rendering the systems useless. Both culverts are likely passable at moderate and higher flow levels. The third culvert, at Soquel Drive, is a more significant barrier and probably precludes upstream migration of adult steelhead or coho at most flow levels (Figure 20). Although the interior of the culvert is fitted with a baffle system similar to the lower two culverts, the lower end of the culvert is perched approximately 4 feet above the downstream bed. There was no pool below the culvert at the time of the survey but it is likely that scour forms one during higher flow conditions. This culvert has been considered for remediation. Swanson Hydrology and Geomorphology has developed designs to ladder the lower end of the culvert and remove the baffles.

Three natural obstacles in reach 2, including a 3-foot cascade and two debris jams, present relatively minor obstacles to adults but probably prevent upstream movement of juveniles under a wide range of flows.

The seventh obstacle in Valencia Creek is the culvert at Valencia Road, approximately 3.4 miles upstream from the Aptos Creek confluence (Figure 21). Although fitted with baffles to improve the potential for migration, the culvert is quite steep (gradient of about 4%) and the lower end is perched about 2 feet above the stream bed. Since this culvert is fairly high in the watershed, flows sufficient for passage may be relatively infrequent. The culvert was recently evaluated using FishXing analytical methods and software. Coastal Watershed Council staff observed a 6-8 inch trout enter this culvert and swim part way through it using the baffle system in early November 2002 (Maya Conrad, Coastal Watershed Council, personal communication, January 2003).

The final obstacle recorded in Valencia Creek is a large debris jam about 1.2 miles upstream from the Valencia Road crossing. The debris jam is sufficiently large and complex that it was judged to prevent upstream migration of both adults and juveniles at most, if not all, flow levels. This jam would likely limit anadromous fish in most years.

Figure 19. First Valencia Creek Culvert

Figure 20. Third Valencia Creek Culvert

Figure 21. Fourth Valencia Creek Culvert, at Valencia Road

3.2.6.4 Trout Creek

No significant obstacles to migration were identified in Trout Creek in the lower 1.3 miles that were surveyed.

3.2.6.5 Mangels Gulch

Two complete barriers to upstream migration of adults and juveniles were identified in the lower part of Mangels Gulch. The first was a 13 foot cascade with associated debris jam located approximately 680 feet upstream from the Aptos Creek confluence. The second was the culvert under Aptos Creek Road that was perched about 5.5 feet above the streambed with no plunge pool below.

4.0 Assessment of Limiting Factors

Populations are always limited in abundance or distribution by some factor, even in pristine systems. When one limit is removed or overcome, another will eventually have an effect. More than one factor may act simultaneously. Limiting factors differ by species, life stage, geographic location, and over time. This assessment focuses on the factor or factors that are most likely to limit steelhead and coho salmon production in the Aptos Creek watershed and which are subject to some type of remediation.

Steelhead and coho salmon populations are generally depressed along the California Central Coast. A logical approach to restoring populations would involve determination of factors that limit a given population so that restoration funds can be most efficiently focused on those factors that are likely to make a difference to a given population. Often important limiting factors are readily apparent (e.g., barriers). In other cases they are more obscure. Given natural variability in environmental conditions and the complexity of steelhead life history, collecting sufficient data to conclusively identify limiting factors is an intimidating proposition. Alternatively, potentially limiting factors must be deduced from careful observation of key habitat features and is best combined with population structure and abundance information.

Common factors that limit production of steelhead and salmon in Central California coastal streams typically include migration obstacles that limit or preclude access to suitable habitat; excessive stream temperature that eliminates rearing potential or truncates migration periods; seasonal elimination of rearing or migration habitat through loss or reduction of stream flow during key periods; reduction of rearing capacity due to lack of instream cover; reduction in recruitment and rearing success due to excessive fine sediment accumulations; excessive mortality due to toxic water quality episodes (gasoline spills, waste disposal, swimming pool discharges, etc.); diminished spawning success due to human disturbance; and reduction in spawning populations due to excessive legal or illegal harvest.

Although challenging to implement, the greatest potential for increasing production of steelhead in the watershed would come from improvements in Valencia Creek since it appears to have experienced far greater decline in productivity than Aptos Creek (Section 1.0). The factors believed to be most limiting in the Aptos Creek watershed are presented in Table 11 and discussed in the following sections. Aptos Creek is in relatively good shape due to the protected status of much of its watershed although improvement in habitat conditions could certainly lead to increased production there as well.

Table 11. Limiting Factors

Stream Reach	Primary Limiting Factor	Secondary Limiting Factors
A-1	Sediment	Rearing cover
A-2	Sediment	Rearing cover
A-3	Sediment	Rearing cover
A-4	Sediment	Rearing cover
A-5	Sediment	Rearing cover
A-6	Adult migration access	Sediment
B-1	Sediment	Adult migration access
V-1	Sediment	Adult migration access
V-2	Adult migration access	Sediment
V-3	Adult migration access	Sediment, low stream flow
Mangels Creek	Lack of summer flow	
Trout Creek	Sediment	Adult migration access, low stream flow

4.1 *Migration Obstacles*

Migration obstacles may limit use of Bridge Creek by steelhead and may limit the ability of steelhead to access upper reaches of Aptos Creek (upstream of reach 5). Migration obstacles in both Bridge Creek and upper reaches of Aptos Creek are caused either by logjams or cascades that, except for possible continuing influence of past timber harvests, are natural in origin. The degree to which any of these obstacles impairs migration is not certain. Although some appear to present more difficult passage than others and a few appear to preclude passage under most conditions, it is likely that they shift over time and therefore present temporary obstacles. The best evidence that these are migration barriers is the low abundance of young-of-year steelhead trout upstream of the log jam defining the break between reach 5 and 6 in Aptos Creek and the absence of any trout upstream of the last recorded log jam in Bridge Creek. A more thorough evaluation, under higher flow conditions, would be needed to more completely assess these obstacles. In any case, they are not likely the primary limiting factors in Aptos or Bridge Creeks.

Migration obstacles are a potentially significant limiting factor in the Valencia Creek watershed. The four mainstem culverts all limit to varying degrees the ability of adult steelhead to access spawning areas and the free movement of juvenile steelhead within rearing areas. Three of the culverts, including one that is probably impassable under most flows, are in the lowest part of the watershed and therefore influence a large proportion of potentially useable habitat. Two of these have been evaluated by Santa Cruz County. Both the culvert under Soquel Drive and the culvert under Valencia Road failed to meet passage criteria for all species of adult salmonids and all age classes of juveniles under all flow conditions (Ross Taylor and Associates 2003). Other obstacles, described in preceding sections, are not likely to form complete barriers to migration of steelhead, rather they act by reducing the periods of time when passage is possible. Although they are a primary limiting factor, removal of barriers in Valencia Creek may have limited benefits for steelhead use of the watershed since significant sediment problems also exist (see below).

4.2 *Temperature*

Based on CDFG monitoring, temperature does not appear to be a limiting factor for either steelhead or coho in Aptos Creek (see earlier discussion of temperature tolerance). Although maximum observed temperatures approached a level at which growth rates of coho may decline, this likely only occurs during brief periods on the warmest days. Temperature was within the optimum range for coho during part of each day on all but a few days. Based on observed similarities in temperature during the habitat survey, this conclusion can probably be extended to Bridge Creek and Valencia Creek as well.

4.3 *Stream Flow*

The magnitude of streamflow is important to rearing salmonids since greater levels of streamflow may increase the area of riffles and production of food organisms, increase the transport of these organisms to areas of the stream inhabited by rearing trout, and for sediment transport and channel forming processes. In upper stream reaches, drainage area decreases, and the level of streamflow becomes insufficient to create deeper water habitat for rearing juvenile trout and salmon or for adults to access these areas to spawn. During summer months conditions become particularly critical with some reaches becoming intermittent or dry. The Aptos and Bridge Creek watersheds are almost completely protected from development and have no significant diversions. Hydrographs within these reaches would be considered unimpaired. Other stream reaches in the basin, including Valencia Creek, Trout Creek, and Mangels Gulch have hydrographs that have been altered by development within the watersheds including water diversions and altered runoff patterns.

Habitat surveys indicated that summer flows appear to be non-existent in Mangels Gulch and this condition is the primary factor limiting steelhead. Although some spawning may occur in tributary streams that dry in summer, with juveniles moving to the mainstem to rear, the substrate in Mangels Creek is dominated by sand and is not suitable for spawning.

Trout Creek also had very low flow during the habitat survey and the channel was dry in some areas. Although the extensive deposits of sand substrate in the channel are probably the primary limiting factor in Trout Creek, low stream flow would be considered an important secondary factor. No trout were observed in Trout Creek. Access to Trout Creek is limited by the three lower culverts in Valencia Creek; however even if access was not a problem, sediment conditions would still preclude use by steelhead or coho.

Low streamflows and narrow, shallow channel conditions were also observed in Valencia Creek, particularly upstream of the Valencia Road culvert. Although trout were present in this reach, their abundance is likely limited by the low streamflow levels although this is probably secondary importance to the high amounts of sand sediment and access issues.

4.4 Rearing Capacity

In Aptos Creek there is abundant habitat for steelhead in their first year of growth in both flatwater and pool habitat types. There is also a significant amount of deep pool habitat available for older trout; however, much of this habitat may be of limited value due to the relative scarcity of food producing riffle habitat. The extent to which riffle habitat limits smolt production would depend on the degree to which juvenile steelhead may use other food sources such as terrestrial insects. Since available abundance data indicates relatively good density of 1+ and older steelhead in Aptos Creek, particularly in the upper reaches, there may not be significant food limitations. Better information on abundance and habitat utilization by 1+ and older fish would be needed to fully evaluate this issue.

Habitat surveys indicated that most reaches of Aptos and Bridge Creeks have shelter conditions that are generally within the range consistent with good steelhead production in comparable streams, although the extent and complexity are at the low end of the range. Pool habitats are quite frequent and generally provide good depth conditions. Much of the pool habitat, particularly in Aptos Creek, is in bedrock formed pools. These pools do not develop extensive undercut banks and do not recruit large woody debris to the same extent as habitats with softer banks. Rearing juvenile trout may be less susceptible to predation if cover was more extensive. The best way to determine whether rearing habitat is limiting for older trout would be to quantitatively assess densities and growth rates of young-of-year and older trout and compare them to other streams. Although steelhead population assessment was not conducted as part of this survey, visual observations and results of previous surveys indicate that both young-of-year and 2nd year and older steelhead/rainbow trout are distributed throughout Aptos Creek and are reasonably abundant.

In many coastal streams, lagoons at the stream mouth can provide important rearing habitat. Lagoons can provide conditions that support rearing of large numbers of juvenile salmonids (Smith 1990, Hagar Environmental Science 2002). Growth rates in lagoons can exceed that in tributary streams and steelhead can reach smolt size in a single season rather than the two years or more it would take in stream habitats (Smith 1990). The Aptos Creek lagoon is compromised in its ability to support steelhead and coho salmon in some important ways. First, it has been reduced in size and compressed between vertical concrete walls for much of its length. It is also enriched by undetermined but presumably unnatural nutrient loading (see companion Water Quality Technical Report). Artificial breaching of the lagoon during summer months can lead to conditions that are unsuitable for salmonid juveniles. The degree to which rearing steelhead use the lagoon has not been the subject of any concerted studies and the importance of lagoon rearing for sustaining steelhead runs in Aptos Creek is unknown. Although, water quality monitoring conducted during the course of this study indicated that there may be suitable habitat in the lagoon for rearing juveniles, it could likely be greatly improved by identifying and controlling sources of nutrient enrichment and other pollutants, controlling artificial breaching, and restoring more natural bank conditions.

4.5 Sediment

Sediment is likely the major factor limiting salmonid production on both a watershed and individual reach scale. Evidence from past sampling indicates that Valencia Creek has had higher densities of rearing trout and lower levels of fine sediments than currently occur and that conditions changed relatively dramatically after sediment deposition during the high flow winter of 1982. Production of trout in Valencia may be reduced by an order of magnitude relative to Aptos Creek since surveys were last conducted in 1981. The greatest increase in steelhead production on a watershed scale would come from restoring the greatly diminished productive capacity of Valencia Creek. Available evidence indicates that, while both Aptos and Valencia Creeks have high rates of sediment loading, Aptos Creek appears to be better able to flush out fine sediments and recover from extreme events. Valencia Creek, perhaps due to high rates of anthropogenic sediment mobilization and altered hydrology due to increased impermeable surfaces from development in the watershed, appears to accumulate fine sediment and recovers very slowly (see companion Geomorphology Technical Report).

Fine sediments also likely diminish the productive capacity of Aptos and Bridge Creeks though not to the same degree as in Valencia Creek. Abundance of young-of-year steelhead was highest in Aptos Creek in reach 5 where the most extensive areas of low embeddedness also occurred (Figures 18 and 22a-c). Densities of young-of-year steelhead were also relatively high in reach 4 and reach 6 but were lowest in reaches 2 and 3 where embeddedness estimates were generally higher (Table 12). Although substrate conditions were better in reach 6 than in reach 5, most of reach 6 was probably not accessible to steelhead and this may be why visual observations of young-of-year trout were much lower in reach 6.

Both young-of-year and older trout were observed in reaches 2 and 3 of Valencia Creek although abundance was relatively low (Table 12). Density estimates for young-of-year were highest in reach 2, downstream of the Valencia Road culvert, where they were comparable to reach 3 of Aptos Creek. As in Aptos Creek, abundance of young-of-year steelhead in Valencia Creek was greatest in areas where spawning areas were observed and where embeddedness ratings were lowest. No trout were seen in Trout Creek and this corresponded to some of the highest levels of fine sediments observed.

Any increase in sediment loading in Aptos Creek has the potential to reduce steelhead productivity and, in the worst case, could induce a threshold response resulting in dramatic declines in the capacity of the watershed to support steelhead such as has apparently occurred in Valencia Creek.

4.6 Water Quality

Water quality issues are a potential concern in the lower, more urbanized parts of the watershed due to contamination from pesticides, herbicides, fertilizers, paint, oil and gas, chlorine from swimming pools and spas, sewage, and other contaminants. More remote parts of the watershed may be subject to contamination related to illegal activities such as methamphetamine production and marijuana cultivation (rat poisons, etc.). Although no obvious water quality problems were identified during the habitat survey, there was a section of Aptos Creek downstream of Mangels

Gulch where no fish were observed. Contamination from sources indicated above would tend to be episodic and difficult to detect.

4.7 Disturbance

Nisene Marks State Park is intensively used by recreationists including runners, mountain bikers, and hikers. Most of Aptos Creek within the Park is accessible to Park users. In the lower part of the Park, trails run along and across the creek in several places. Road crossings also occur at two locations. Creek crossings are frequently at pool/riffle transitions in areas suitable for spawning steelhead and coho salmon. Use of crossings by hikers and bikers could disturb spawning activity and damage eggs and pre-emergent fry in the substrate. Hiking off trail, in or along the creek, could also disturb spawning activity.

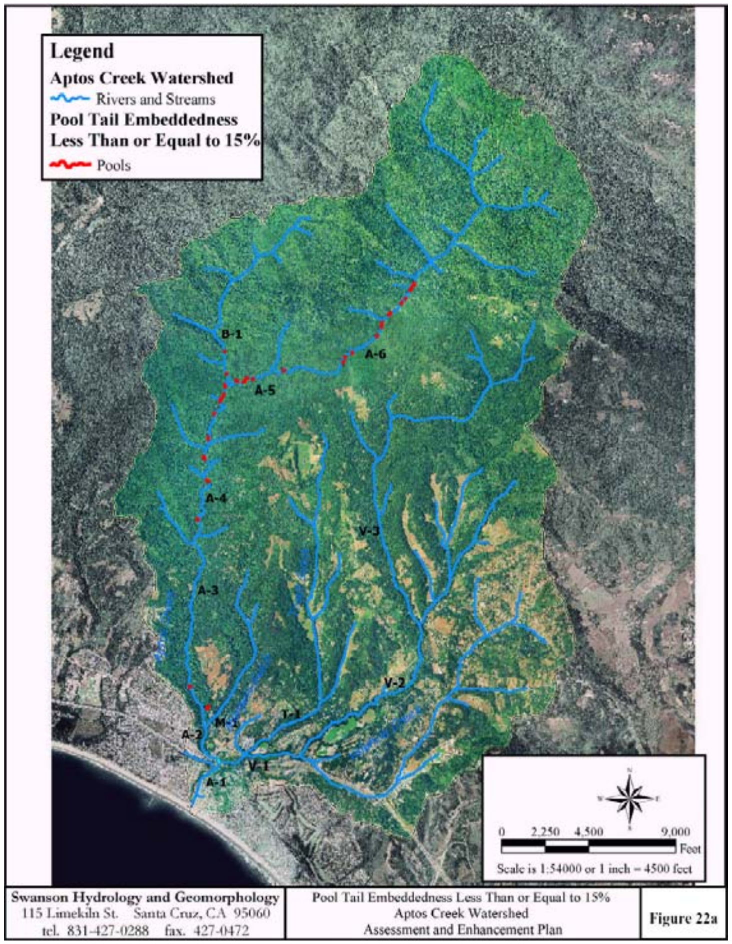
In numerous locations, Park users have piled cobbles across pool tail areas. These cobble dams obstruct free movement of juvenile trout and salmon and may obstruct adults migrating early in the season or at lower flows.

In some parts of Valencia and Trout Creeks, landowners adjacent to the creek have modified stream banks or riparian vegetation to the possible detriment of steelhead and salmon.

It is difficult to judge the potential impact of any of these activities although none of them is likely to act as a major limiting factor. Nevertheless, the disturbance may be susceptible to greater control through educational programs and reduction in the level of disturbance would be beneficial.

4.8 Exploitation

Existing fishing regulations allow fishing for steelhead in Aptos Creek from the mouth to the Steel Bridge between November 16 and February 28. Fishing is restricted to Wednesdays, Saturdays, Sundays, legal holidays, and the season opening and closing days. Only barbless hooks may be used and all caught fish must be released. The rest of the stream, upstream of Highway 1, is closed to fishing all year. The level of angler use, legal or illegal, is not consistently monitored and is unknown. Although the habitat survey did not specifically address this issue, nothing was encountered during the habitat survey that would indicate high levels of legal or illegal fishing.



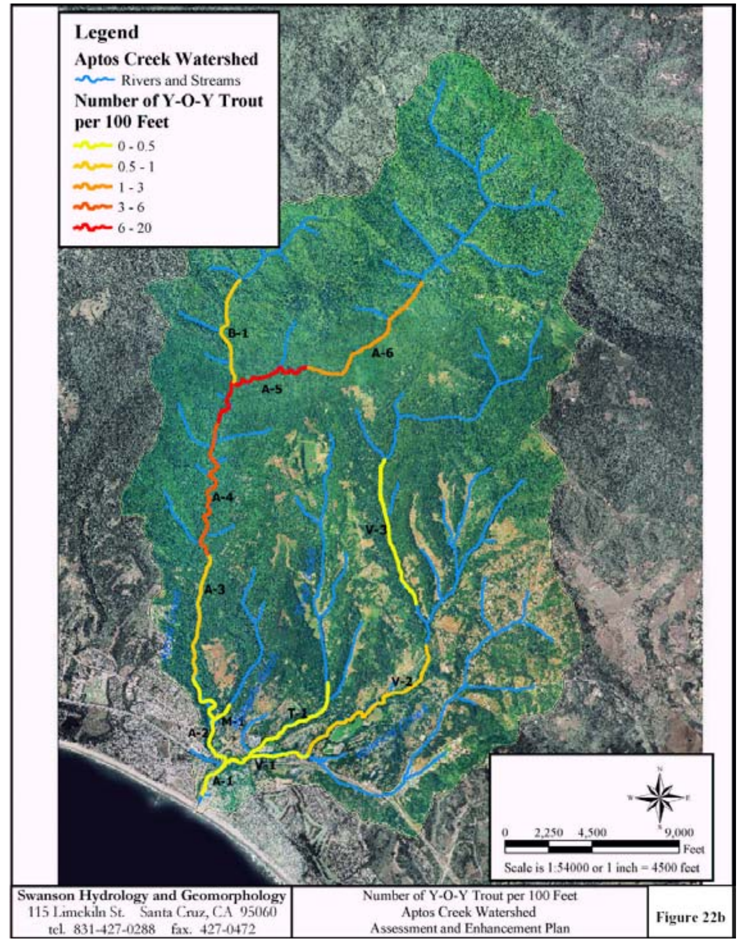


Figure 22a-c. Watershed Embeddedness Estimates and Frequency of Observations of Young-of-Year Steelhead/Rainbow Trout

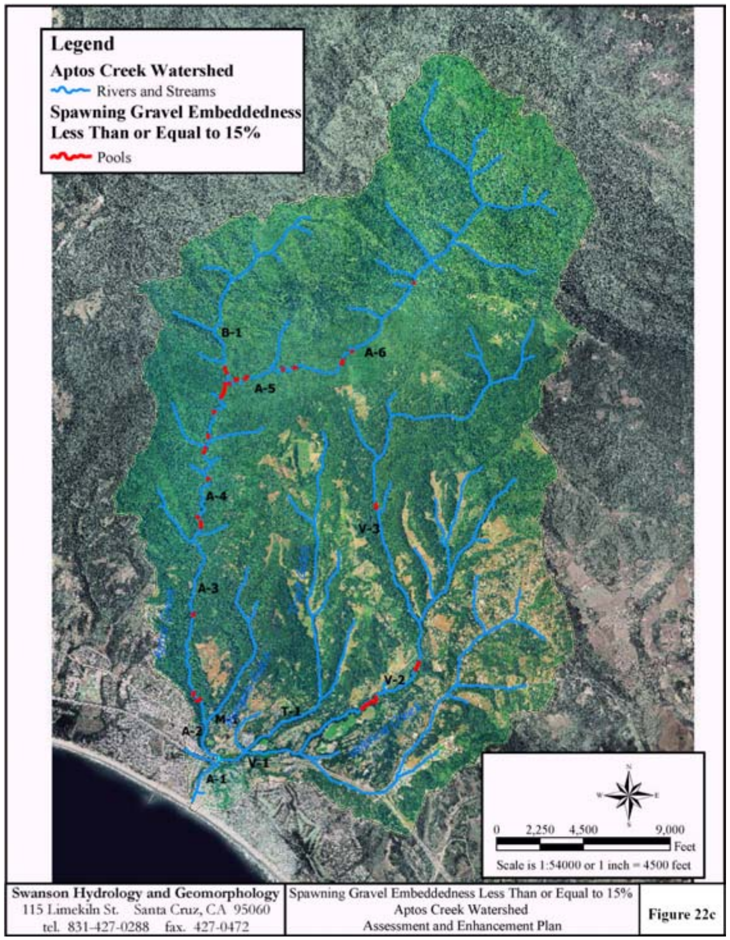


Figure 23a-c. Watershed Embeddedness Estimates and Frequency of Observations of Young-of-Year Steelhead/Rainbow Trout (cont.)

Table 12. Trout Observed during Habitat Inventory by Reach

	Aptos Creek						Bridge Creek	Valencia Creek			Trout Creek	Mangels Creek
	A-1	**A-2**	**A-3**	**A**	**A-5**	**A-6**	**B-1**	**V-1**	**V-2**	**V-3**	**T-1**	**M-1**
Trout 4 in. or less (TL in.)	0	31	58	609	1143	146	59	0	79	34	0	0
Trout over 4 in. (TL in.)	0	16	22	27	20	21	10	0	13	10	0	0
Sum of Habitat Length (feet)	1649	7134	8340	10366	9251	7952	6461	5599	12581	9232	7018	1452
Y-O-Y/100 feet (<4 in.)	0.00	0.43	0.70	5.87	12.36	1.84	0.91	0.00	0.63	0.37	0.00	0.00
Older trout/100 feet (>4 in.)	0.00	0.22	0.26	0.26	0.22	0.26	0.15	0.00	0.10	0.11	0.00	0.00

Notes: in.: inches
TL: total length
Y-O-Y: young-of-year

	Aptos Creek						Bridge Creek	Valencia Creek			Trout Creek
		A-2	**A-3**	**A-**	**A-5**	**A-6**	**B-1**	**V-1**	**V-2**	**V-3**	**T-1**
Y-O-Y/100 feet (<4 in.)	0.00	0.43	0.70	5.87	12.36	1.84	0.91	0.00	0.63	0.37	0.00
Spawning Area (square feet) per 100 feet	0.0	3.6	3.0	4.4	2.3	1.7	0.4	0	0.1	0.1	0
% units with pool tail embeddedness <=15%	n.a.	8%	0%	14%	28%	41%	10%	n.a.	n.a.		n.a.
% spawning areas with embeddedness <=15%	n.a.	23%	11%	33%	75%	31%	100%	n.a.	75%	50%	n.a.

Notes: in.: inches
TL: total length
Y-O-Y: young-of-year

4.9 Coho Salmon

Coho salmon have declined dramatically in streams south of San Francisco Bay. Coho salmon were present in Aptos Creek as recently as 1973 (Anderson 1995). Nearly the entire Aptos Creek watershed is maintained in natural condition as State Park lands and supports a relatively healthy steelhead population. Therefore, the disappearance of coho from Aptos Creek cannot be linked to human activities in the watershed such as residential development, water extraction, timber harvest, or road construction, which may be a factor in other streams. It is more likely that the major factors currently limiting coho in Aptos Creek are external to the watershed or are the result of natural environmental events that have impacted coho to a far greater degree than steelhead.

It is likely that ocean conditions are a significant factor in abundance of coho south of San Francisco Bay. Anderson (1995) points out that the sharp decline or extirpation of coho south of San Francisco Bay in the late 1970's and early 1980's was coincident with a warming trend along the Washington-California coast from 1976 to 1983 and with the severe drought in 1976-1977. Certainly, declining abundance of species at the extremes of range and contraction in range is expected (and widely demonstrated in terrestrial species) in response to long-term climate change. Still, coho maintain populations in nearby Central Coast streams that are, presumably, also impacted by these conditions (e.g., Waddell Creek and Scott Creek).

Due to its rigid 3-year female brood lineages, coho may have been eliminated from Aptos Creek as a result of very poor conditions in a few years. For example, 1972 was a very dry year with flow rarely exceeding 2 to 3 cfs through the winter and declining to about 0.5 cfs during the summer. This would have been a poor year for spawning and reproduction and would have influenced the return of the brood year lineage spawning in 1975, 1978, and 1981. The drought of 1976-1977 could have resulted in poor spawning and recruitment thus impacting the other two female lineages, spawning in 1979 and 1980. The extreme winter of 1982 resulted in near complete loss of rearing habitat and may have seriously reduced the abundance of rearing juveniles from the 1981 brood year that would have spawned in 1984, as well as wiping out eggs or fry and eliminating rearing habitat for the 1982 year class that would have spawned in 1985.

It may be that the primary factor currently limiting coho in Aptos Creek is simply that there is no spawning population. Coho, like other Pacific salmon, will inevitably stray to suitable habitat given sufficient time and the proximity of a viable population. The nearest viable populations occur in Scott and Waddell Creeks. The likelihood that fish will stray from these populations is influenced by their ocean behavior, response to currents and food sources, and abundance. It does not apparently occur with high frequency presently. It may be that reintroduction of coho would be a necessary prerequisite to establishing a population in the near term. The Aptos Watershed Restoration and Management Plan is focused on habitat management and restoration. Reintroduction of coho salmon is an issue that will be addressed by others in other forums, such as the coho salmon recovery team convened by the National Marine Fisheries Service. Until fish are present in the stream it is difficult to predict precisely what may be influencing their abundance there. Beyond limitations imposed by lack of a spawning population and ocean conditions, coho would likely be limited by many of the same factors limiting steelhead as discussed in the preceding section, particularly sediment. Coho at the emergence stage are slightly more sensitive to fine sediments than steelhead (Phillips *et al.* 1975 in Reiser and Bjornn 1979), possibly due to their larger size at hatching.

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